

Jožef Stefan Institute - Annual Report 2007



Annual report 2007

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INTRODUCTION

The Jožef Stefan Institute is the main Slovenian research institution involved in high-level research and the development of nanotechnologies, new materials, biotechnologies, the technologies of management and production, communication technologies, computer and knowledge technologies, environmental technologies, and reactor technologies. The institute puts an equal emphasis on creativity and the dissemination and transfer of knowledge as it does on technologies aimed at supporting sustainable development. At the end of 2007 the institute had 854 employees, of which a good majority have PhDs or are PhD students. The basic activities of the institute were carried out within 26 research departments, involved in the areas of natural science, life science, and engineering science. The institute is characterised by an interdisciplinary approach, combining various scientific activities in the areas of basic research, education and development that supports the national economy.

The Annual Report for 2007 demonstrates the high quality and international level of our research-and-development activities. I am also pleased to note that the numerical indicators relating to the institute's business operations in the past three years, established at the end of 2007, also show significant positive changes. We have also noted a significant increase in the extent of the activities organised within industrial and European projects, and exceptional progress in the development of scientific excellence. I would especially

like to point out that the institute has made tremendous efforts with respect to bringing scientific research closer to the expectations and requirements of the national and European economies. Over the past three years, the institute increased its revenues by more than 25 percent, which is mainly achieved by increasing the scope of its industrial and European projects. In 2007 alone, the institute was carrying out 234 projects for industry. In addition, during the same period, the indicators of research excellence were also very much on the increase, as the annual number of publications in journals with an impact factor increased by more than 22 percent, while the annual number of citations increased by more than 60 percent.

The institute acts as an equal partner within a large number of international projects and networks. Its competitiveness is based on high-quality research-and-development activities and also on international cooperation. People say that if two friends exchange two objects, each of them will again have, after the exchange, one object only; but when they exchange ideas, each of them will have two ideas after their exchange. To this beautiful idea I have to add my own belief that, in the case of such an exchange, the arithmetic is even more favourable. Namely, if we bring together two ideas, many more will arise from them. Once we have built bridges between ideas, experiences and cultures, wonderful and unexpected possibilities of entering new spaces open up, possibilities that we did not even know of, or anticipate, at the beginning.

In 2007 a lot of important scientists from all over the world, as well as important figures from the social and political spheres, visited the institute. Among them, I would like to mention the visits of Dr. Vasko Simoniti, the Minister of Culture, Dr. Milan Zver, the Minister of Education and Sport, Dr. Gregor Virant, the Minister of Public Administration, Zofija Mazej



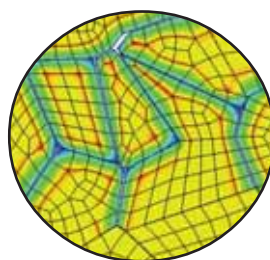
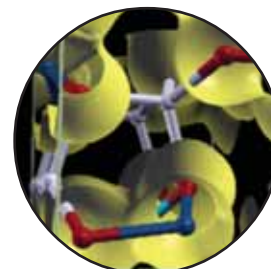
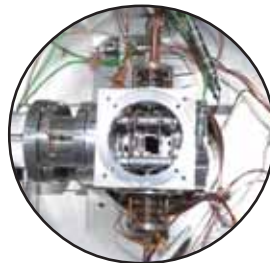
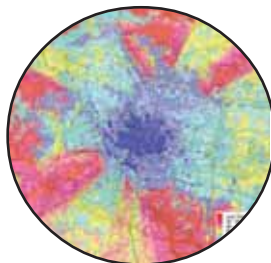
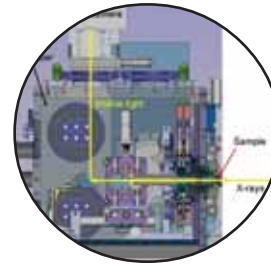
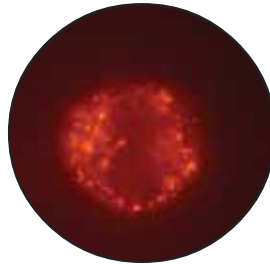
*Director of the Jožef Stefan Institute
Prof. Jadran Lenarčič*

Kukovič, the Minister of Health, Mojca Kucler Dolinar, the Minister of Higher Education, Science and Technology, and Dr. Žiga Turk, the Minister for Growth. I would also like to point out that in December the institute awarded, with the full support of the institute's researchers, the highest award, the award of Institute Honorary Member, to its long-serving colleague, and academic, Prof. Robert Blinc.

In most cases we cannot influence our destiny, because other forces make us take a specific path that we cannot leave; however, we can always find a meaning in what we do. For this reason, I would like to take this opportunity to express my respect for, and acknowledge, my colleagues and friends at the institute, in Slovenia and abroad who have dedicated their lives, sometimes acting in difficult conditions and gaining no recognition, to research and development, which they saw, not as a safe haven, but as a mission and a privilege, enabling them to contribute towards human well-being.



*Prof. Jadran Lenarčič
Director of the Jožef Stefan Institute*



A BRIEF HISTORY OF THE JOŽEF STEFAN INSTITUTE

1946

- ~ Decision taken by the Slovenian Academy of Science and Arts to build a Physics Institute

1949

- ~ Research connected to the peaceful use of atomic energy started, financed by the Federal Government

1952

- ~ Institute renamed the Jožef Stefan Physics Institute and moved to new laboratories on its present site

1954

- ~ The betatron and an electron microscope installed as the institute's first major pieces of equipment

1956

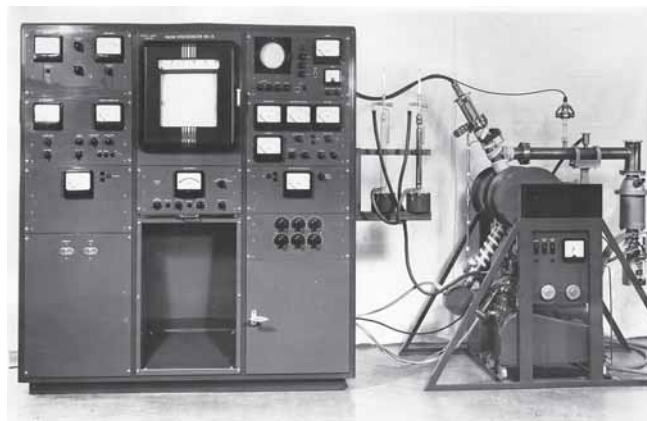
- ~ Van de Graaff accelerator, constructed at the institute, started operation

1958

- ~ Institute reorganised and new fields of activity defined: nuclear physics, solid-state physics, chemistry, and radiobiology

1959

- ~ Institute renamed the Jožef Stefan Nuclear Institute. The major source of income was provided by the Yugoslav Atomic Energy Commission



Mass spectrometer at the JSI (about 1960)

1962

- ~ One of the first compounds of a noble gas, XeF₆, synthesised at the institute
- ~ The first computer for research, ZUSE Z 23, installed

1966

- ~ Nuclear research reactor TRIGA starts operation

1968

- ~ Yugoslav Atomic Energy Commission ceases to operate; The Republic of Slovenia becomes the institute's dominant source of research funding

1969

- ~ Institute is renamed as the Jožef Stefan Institute

1970

- ~ University of Ljubljana becomes a co-founder of the Jožef Stefan Institute, together with the Federal Executive Council

1971

- ~ A new unit, INOVA, established with the aim of applying the institute's expertise and output to productive use in the national economy



Institute buildings after the opening 1953

1972

- ~ New computer Cyber 72 purchased, and the Republic Computer Centre established as an independent unit of the Jožef Stefan Institute

1974

- ~ Collaboration with the international centre CERN in the field of high-energy physics started
- ~ SEPO group for evaluating environmental interventions is established

1976

- ~ First Yugoslav 8-bit processor computer DARTA 80

1979

- ~ Contract defining cooperation between the Jožef Stefan Institute and the Nuclear Power Plant Krško is signed
- ~ First robot in Slovenia constructed

1982

- ~ Ecological Laboratory with Mobile Unit established as a special unit of the Slovenian Civil Protection Organisation

1983

- ~ Stefin, a cysteine proteinase inhibitor named after Jožef Stefan, isolated and its primary structure determined



The Reactor Centre, Podgorica, built in 1966

1985

- ~ "2000 New Young Researchers" project established by the Slovenian Research Council
- ~ Centre for Hard Coatings established by the Jožef Stefan Institute and the firm SMELT

1987

- ~ INEA established by the Jožef Stefan Institute as an independent company to promote technology transfer in the fields of cybernetics and energy management



Nuclear magnetic resonance spectrometer

1989

- ~ Milan Čopič Nuclear Training Centre established

1990

- ~ The first Slovenian supercomputer, CONVEX, installed at the Jožef Stefan Institute
- ~ Construction of new laboratories completed

1992

- ~ New technology centres established by the Ministry of Science and Technology
- ~ Jožef Stefan Institute restructured by the Slovenian Government as a public research institution
- ~ Jožef Stefan Technology Park founded, later to become the Ljubljana Technology Park

1995

- ~ Jožef Stefan Institute is a co-founder of the international postgraduate school for environmental sciences, the Nova Gorica Polytechnic

- ~ Research institutes in Velenje, ERICo and Valdoltra established by the institute

1997

- ~ 3.5-MeV electrostatic accelerator, TANDETRON, installed

1999

- ~ Jožef Stefan Institute celebrates its 50th anniversary

2003

- ~ Jožef Stefan International Postgraduate School established

2004

- ~ Jožef Stefan Institute is chosen as the coordinator of four Research Centres of Excellence

2007

- ~ nanomanipulation of single atoms using low-temperature scanning tunneling microscope
- ~ New ERDA/RBS beamline installed at TANDETRON accelerator at Microanalytical center



The beginnings of robotics at the JSI, in 1985

FORMER DIRECTORS



*Prof. Anton Peterlin,
first Director of the Jožef Stefan Institute*

Prof. Anton Peterlin, Founder and first Director of the Jožef Stefan Institute, 1949 - 1955

Karol Kajfež, 1955 - 1958

Lucijan Šinkovec, B. Sc., 1959 - 1963

Prof. Milan Osredkar, 1963 - 1975

Prof. Boris Frlc, 1975 - 1984

Prof. Tomaž Kalin, 1984 - 1992

Prof. Danilo Zavrtanik, 1992 - 1996

Prof. Vito Turk, 1996 - 2005

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Complex Matter (F-7)

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Prof. Tomaž Kosmač

Nanostructured Materials (K-7)

Prof. Spomenka Kobe

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Prof. Gorazd Kandus

Computer Systems (E-7)

Prof. Franc Novak

Knowledge Technologies (E-8)

Prof. Nada Lavrač

Intelligent Systems (E-9)

Prof. Matjaž Gams

Reactor Techniques and Energetics

Reactor Engineering (R-4)

Prof. Borut Mavko

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Science Information Centre (SIC)
Dr. Luka Šušteršič

Energy Efficiency Centre (EEC)
Tomaž Fatur, M. Sc.

Centre for Knowledge Transfer in Information Technologies (CT-3)
Milja Jermol, M. Sc.

Milan Čopič Nuclear Training Centre (ICJT)
Prof. Igor Jenčič

Helium Liquifier with Superconducting Magnet and Helium Regeneration System
Milan Rožmarin, B. Sc.

Mass Spectrometry Centre
Dr. Bogdan Kralj

National Centre for Microstructure and Surface Analysis
Prof. Marija Kosec

Centre for Electron Microscopy (CEM)
Asst. Prof. Miran Čeh

Microanalytical Instrumental Centre (MIC)
Dr. Primož Pelicon

National High Resolution NMR Spectroscopy
Prof. Janez Dolinšek

ADMINISTRATION, SERVICES AND SUPPORT UNITS

Administration and Services

Legal and Personnel (U-2)
Marta Slokan Butina, LL. B.

Sales and Purchase Department (U-3)
Jože Kašman, B. Sc.

Finance and Accounting (U-4)
Regina Gruden, B. Econ.

Public Relations
Polona Strnad, B. Sc.

Technical Services (TS)
Slavko Zalar, B. Sc.

Support Units

Technology Transfer Office (U-9)
Prof. Peter Stegnar

Radiation Protection Unit (SVPIS)
Bogdan Pucelj, M. Sc.

Quality Assurance (QA)
Ljubo Fabjan, M. Sc.

Centre for Business Applications (CPO)
Mato Nowak, B. Sc.

Workshops
Bogdan Veber, B. Sc.

PARTICIPATION IN REGIONAL DEVELOPMENT OF RESEARCH

Ljubljana Technology Park Ltd.

Founders:
Jožef Stefan Institute
National Institute of Biology
National Institute of Chemistry
Lek
City of Ljubljana
Iskra Sistemi
IskraTel

University of Nova Gorica

Founders:
Jožef Stefan Institute
Nova Gorica Municipality
Ajdovščina Municipality
Scientific Research Centre of the Slovenian
Academy of Sciences and Arts, Ljubljana

Jožef Stefan International Postgraduate School

Founders:
Jožef Stefan Institute
Gorenje, Velenje
Kolektor Group, Idrija
Salonit, Anhovo
Slovenian Insurance Association, Ljubljana

Technology Centres

**Technology Centre for Production
Automation, Robotics and
Informatics (ARI)**

**Security Technology
Competence Centre (SETCCE)**

**Technology Centre for Circuits,
Components, Materials,
Technologies and Equipment for
Electrotechnic (TC SEMTO)**

MANAGEMENT

DIRECTORATE

Director JSI

Prof. Jadran Lenarčič

Assistants to the Director

Darko Korbar, M. Sc., MBA

Dr. Boris Pukl

Counsellors

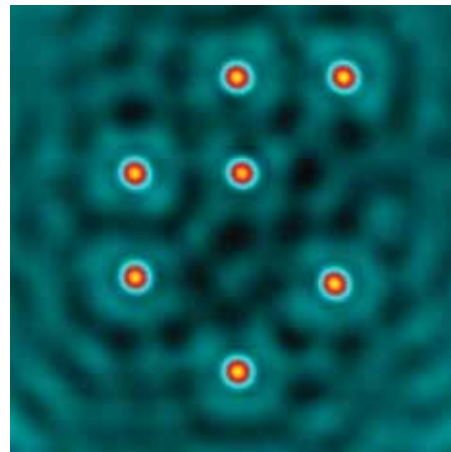
Prof. Peter Prelovšek

Prof. Jurij Franc Tasič

Adviser

Borut Lavrič, LL. B.

The first successful manipulation of single copper atoms (6th July 2007) Logo of J. Stefan Institute, "JSI", assembled by manipulating Cu atoms on a Cu(111) surface at 9K, using a low-temperature Scanning Tunneling Microscope, built at the JSI. (E. Zupanič et al.)



BOARD OF GOVERNORS

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Prof. Anton Jeglič, Ministry of Higher Education, Science and Technology

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Prof. Dragan Dragoljub Mihailović, JSI

Asst. Prof. Milko Novič, Ministry of Higher Education, Science and Technology

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Peter Puhan, M. Sc., Ministry of the Economy (until December 2007)

Prof. Franc Strle, University Medical Centre Ljubljana

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Prof. Boris Žemva, JSI

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Prof. Matjaž Gams (since January 2007)

Prof. Milena Horvat, Deputy President

Prof. Nada Lavrač (since January 2007)

Prof. Jadran Lenarčič

Prof. Andrej Likar, Deputy President

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Prof. Dragan Dragoljub Mihailović (since January 2007)

Prof. Marko Mikuž

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Prof. Franc Novak

Prof. Peter Prelovšek

Prof. Stanislav Strmčnik

Prof. Danilo Suvorov

Prof. Vito Turk

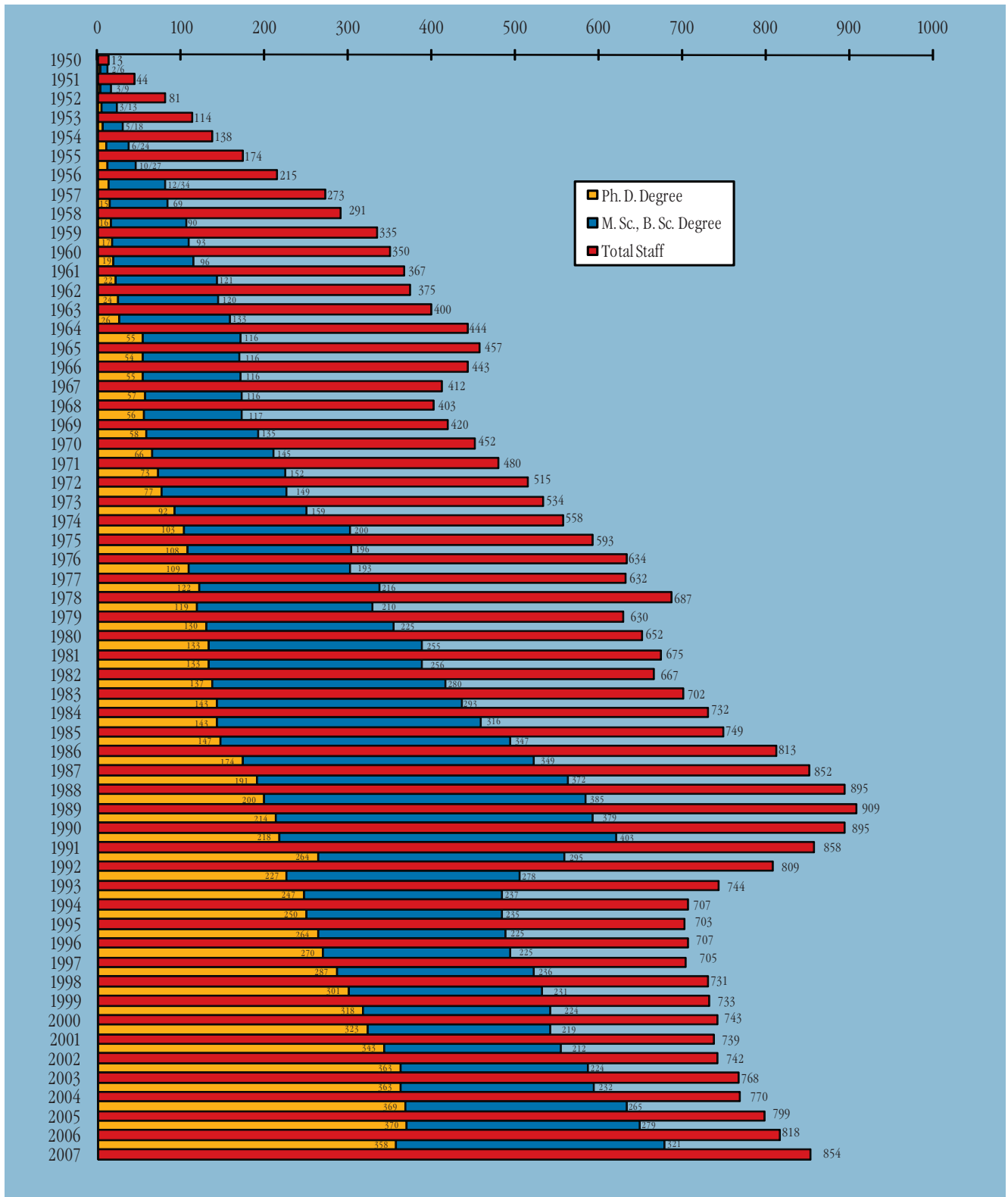
Prof. Boris Žemva (until January 2007)



Prof. Marija Kosec, President of the Scientific Council

STAFF QUALIFICATIONS

1949-2007



ASSOCIATE MEMBERS, ADVISERS AND EMERITUS SCIENTISTS

HONORARY MEMBERS

- Prof. Robert Blinc**, President of the Scientific Council from 1992 to 2007
Prof. Boris Frllec, Director of the Jožef Stefan Institute from 1975 to 1984
Prof. Robert Huber, *Nobel Prize Winner*, Max-Planck-Institut für Biochemie, Munich, Germany
Prof. Milan Osredkar[†], Director of the Jožef Stefan Institute from 1963 to 1975 (1919 - 2003)
Prof. Anton Peterlin[†], Founder and First Director of the Jožef Stefan Institute from 1949 to 1955 (1908 - 1993)

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Prof. Vlado Valković, Zagreb, Croatia
Prof. John Waugh, M.I.T., Cambridge, Massachusetts, USA

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Prof. Darko Jamnik
Prof. Gabrijel Kernel
Prof. Miodrag V. Mihailović

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Zdravko Gabrovšek, B. Sc., Slovenia
Prof. Dušan Hadži, National Institute of Chemistry, Ljubljana, Slovenia
Prof. Karl A. Müller, *Nobel Prize Winner*, IBM Research Laboratory, Zurich, Switzerland
Prof. Bogdan Povh, Max-Planck-Institut für Kernphysik, Heidelberg, Germany
Prof. Momčilo M. Ristić, Academy of Science of Serbia, Belgrade, Serbia and Montenegro
Milan Slokan, M. Sc., Ljubljana, Slovenia
Prof. Petar Strohal, Zagreb, Croatia
Prof. Črt Zupančič, Ludwig-Maximilians-Universität, Munich, Germany
Dr. Novak Zuber, Nuclear Regulatory Commission, Washington D. C., USA



Prof. Robert Blinc, honorary member of the JSI, 12 December 2007

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Prof. Dietrich Munz, Universität Karlsruhe, Karlsruhe, Germany

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Prof. John Ryan, University of Oxford, Oxford, United Kingdom

Prof. Volker Sörgel, Ruprecht-Karis-Universität, Heidelberg, Germany

Prof. H. Eugene Stanley, Boston University, Boston, Massachusetts, USA

Prof. Thomas Walcher, Universität Mainz, Mainz, Germany

INTERNATIONAL COOPERATION AGREEMENTS

In 2007, cooperation agreements were signed between the Jožef Stefan Institute and:

1. Korea Basic Science Institute (KBSI), Korea
2. Los Alamos National Laboratory, Los Alamos, USA
3. Zavoisky Physical-Technical Institute, Kazan, Russia
4. Faculty of Chemistry and Technology of National Technical University of Ukraine, Kiev, Ukraine
5. Institute of Chemistry Karl-Franzens University Graz, Graz, Austria
6. European Virtual Institute for Integrated Risk Management, Stuttgart, Germany
7. Institute of Food Research, Norwich, Great Britain
8. b-Cat b.v. B.V., Tiel, The Netherlands
9. Academy of Sciences of the Czech Republic, Prague, Czech Republic
10. Cycorp, Inc, Austin, Texas, USA
11. Laboratory for Data Acquisition, Processing and Transmission, Faculty of Automatic Control and Computer Science, Bucharest, Romania
12. The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology, Norway
13. Ruder Bošković Institute, Zagreb, Croatia



In 2007 we signed a cooperation agreement with the Korean Basic Science Institute.

INTERNATIONAL COOPERATION

Multilateral international cooperation	No. of projects
7. FP - EURATOM	16
6. FP (LIFESCIHEALTH, IST, NMP, AERO, TREN, SPACE, FOOD, ENERGY, TRANSPORT, GLOBAL, CITIZENS, SSP, NEST, SME, INCO, ERA-NET, MOBILITY, INFRASTRUCTURES, SCIENCE AND SOCIETY, RESEARCH/INNOVATION POLICIES, EURATOM)	88
5. FP (QoL, IST, GROWTH, EESD, INCO, IPS, IHP)	2
IEE	10
LEONARDO DA VINCI, SOCRATES / MINERVA, ERASMUS	4
EUREKA	1
COST	14
NATO (SP, CLG, RIG)	6
IAEA	12
ESF (EMAR)	2
UNESCO-ROSTE	1
INTERREG III C	1
INTAS	2
ERA-NET (MATERA)	6
PHEA, HFSP0	2
OTHERS (DELPHI, HERA-B, ATLAS, CERN RD-39, CERN RD-42, CERN RD-50, BELLE, CIMA, IHFSP, CAMP, IRE, PHARE, ESF)	21
TOTAL	188

Bilateral cooperation	No. of projects	Bilateral cooperation	No. of projects
Albania	1	Japan	5
Argentina	2	Korea	1
Austria	11	Macedonia	5
Belgium	3	Montenegro	1
Bosnia and Herzegovina	5	Norway	2
Bulgaria	1	Poland	3
China	13	Portugal	3
Croatia	14	Romania	3
Cyprus	1	Russia	2
Czech Republic	4	Serbia	3
Denmark	1	Slovakia	2
Finland	2	Switzerland	1
France (PROTEUS - 12)	17	The Netherlands	4
Germany	5	Turkey	4
Greece	6	Ukraine	6
Hungary	6	United Kingdom (PSP - 1)	4
India	2	USA	9
Italy	13	TOTAL	165

FORMAL GOVERNMENTAL DELEGATIONS AND VISITORS

Dr. Meyer-Krahmer, German State Secretary for Education and Science
January 11, 2007

Dr. Vasko Simoniti, Minister of Culture
March 19, 2007



Mrs. Mojca Kucler Dolinar, Minister for Higher Education, Science and Technology at the JSI

Dr. Milan Zver, Minister of Education and Sport
March 23, 2007

Dr. Ronald Segal, Undersecretary of the US Air Force
June 2, 2007

Mrs. Kristine Edlinger-Ploder, Landesrätin, member of the provincial government
from Austrian Styria

Dr. Jure Zupan, Minister for Higher Education, Science and Technology
July 6, 2007

Dr. Gregor Virant, Minister of Public Administration
October 8, 2007

Mrs. Mojca Kucler Dolinar, Minister for Higher Education, Science and Technology
October 9, 2007

Mr. Zoran Janković, Mayor of Ljubljana Municipality
November 7, 2007

Dr. Žiga Turk, Minister for Growth
November 21, 2007

Mrs. Zofija Mazej Kukovič, Minister for Health
December 4, 2007

Dr. Dušan Lesjak, State Secretary, Ministry for Higher Education, Science and Technology
December 12, 2007

Mrs. Mojca Kucler Dolinar, Minister for Higher Education, Science and Technology
December 12, 2007

ART EXHIBITIONS AT THE JSI

Tanja Špenko, January 29–February 26, 2007

Jerca Šantej, February 28–March 16, 2007

Gustav Gnamuš, March 19–April 12, 2007

Ron Preinfalk, April 16–May 11, 2007

Wooden ecclesiastical architecture of Central Europe, May 15–June 1, 2007

Robert Lozar, June 4–June 28, 2007

Andrej Blatnik, July 2–July 26, 2007

Angelo Rinaldi, July 30–August 17, 2007

Barbara Jurkovšek, August 20–September 20, 2007

Marjan Dovjak, September 24–October 18, 2007

Marija Flegar, October 22–November 12, 2007

Tanja Vujinovič, November 14–November 22, 2007

Jure Poša, November 26–December 13, 2007

Andraž Šalamun, December 17, 2007–January 17, 2008



Gustav Gnamuš at the opening of exhibition of his work in the presence of the Director of the JSI, Prof. Jadran Lenarčič and the Slovenian Minister of Culture, Prof. Vasko Simoniti

COOPERATION WITH UNIVERSITIES

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53. **Prof. Boštjan Žekš**, Academician, University of Ljubljana, Faculty of Medicine
54. **Prof. Slobodan Žumer**, University of Ljubljana, Faculty of Mathematics and Physics

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3. **Dr. Marijan Maček**, University of Ljubljana, Faculty of Electrical Engineering
4. **Dr. Saša Prelovšek Komelj**, University of Ljubljana, Faculty of Mathematics and Physics
5. **Dr. Tomaž Rejec**, University of Ljubljana, Faculty of Mathematics and Physics
6. **Dr. Barbara Rovšek**, University of Ljubljana, Faculty of Mathematics and Physics
7. **Dr. Darko Veberič**, University of Nova Gorica
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32. **Dr. Andrej Zorko**, University of Ljubljana, Faculty of Natural Sciences and Technology and Faculty of Chemistry and Chemical Technology
33. **Anže Zupanc, B. Sc.**, University of Ljubljana, Faculty of Mathematics and Physics

INSTITUTE COLLOQUIA

January 17, 2007: **Asst. Prof. Maja Remškar**

Jožef Stefan Institute, Ljubljana, Slovenia

Risks during the production and application of nanoparticles

January 31, 2007: **Dr. Denis Pompon**

Centre de Génétique Moléculaire, CNRS, Gif-sur-Yvette, France

Surface plasmon resonance imagery and single molecule approaches of proteo-nucleic complex self-assembly

February 21, 2007: **Asst. Prof. Simon Širca**

Jožef Stefan Institute and University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana, Slovenia

Proton microscopy: Pentateuch of electron scattering

March 7, 2007: **Dr. Diane Eichert, Dr. Luca Gregoratti, Dr. Burkhard Kaulich**

ELETTRA - Sincrotrone Trieste, Italy

Microscopic techniques at the Elettra synchrotron in Trieste

March 20, 2007: **Prof. Jože Rakovec**

University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana, Slovenia

Energy conversions in the atmosphere

March 21, 2007: **Prof. Jacques Livage**

Chimie de la matière Condensée Collège de France, Paris, France

Bio-inspired silica glasses

March 22, 2007: **Prof. Marija Kosec**

Jožef Stefan Institute, Ljubljana, Slovenia

Ceramic materials for the electronics of the next generation

April 10, 2007: **Dr. Oliver Gutfleish**

Institute for Metallic Materials, Dep. Magnetism & Superconductivity, Leibniz-Institut für Festkörper - und Werkstofforschung, Dresden, Germany

Novel functional magnetic materials based on magneto-structural phase transformations

April 25, 2007: **Dr. Henk Van As**

Lab of Biophysics and Wageningen NMR Centre, Wageningen University, Netherlands

Non-invasive assessment of food products by time domain NMR and MRI

May 9, 2007: **Dr. Chris P. Ewels**

Institute of Materials (IMN), CNRS, Nantes, France

Topology, structure and defects in carbon nanosystems

June 20, 2007: **Prof. Dirk van der Marel**

Département de Physique de la Matière Condensée, Université de Genève, Switzerland

Can high T_c superconductivity be explained with the BCS model? An optical approach.

June 27, 2007: **Prof. Julia A. Kornfield**

Department of Chemistry and Chemical Engineering, California Institute of Technology, USA

Sculpting implants in situ: Light adjustable intraocular lenses

September 5, 2007: **Dr. Stanislav Južnič**

Institute of Mathematics, Physics and Mechanics, Ljubljana, Slovenia

Anton Peterlin: scientist, professor, director, politician and mountaineer

September 28, 2007: **Prof. Karl O. Christe**

University of Southern California, USA

Chemistry of polynitrogen molecules

October 10, 2007: **Prof. Iztok Arčon**

University of Nova Gorica, Slovenia

Nanostructured analyses: new challenges in X-ray absorption spectroscopy

October 24, 2007: **Prof. Alan Seabaugh**

University of Notre Dame, USA

Energy-efficient transistors

November 7, 2007: **Dr. Mladen Horvatić**

CNRS Grenoble, France

Science in very high magnetic fields: NMR investigations of exotic quantum spin states

November 21, 2007: **Dr. J. C. Loudet**

Centre de Recherche Paul Pascal (CRPP) - CNRS, Pessac, France

Wetting and contact lines of micrometer-sized ellipsoids

November 30, 2007: **Prof. Bogdan Povh**

Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Physical methods for the determination of element concentrations in microstructures

December 12, 2007: **Prof. Malcolm I. Heggie**

Department of Chemistry and Biochemistry, University of Sussex, Brighton, UK

Graphite - a new twist

December 19, 2007: **Prof. Saw-Wai Hla**

Ohio University, USA

STM atom/molecule manipulation: Realizing single molecule devices

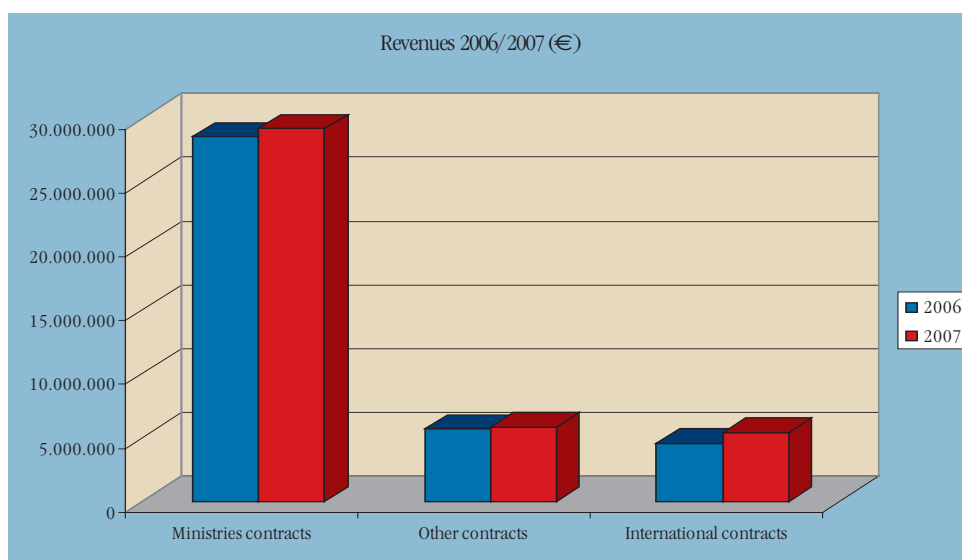


Saw-Wai Hla: Images demonstrating STM manipulation products.

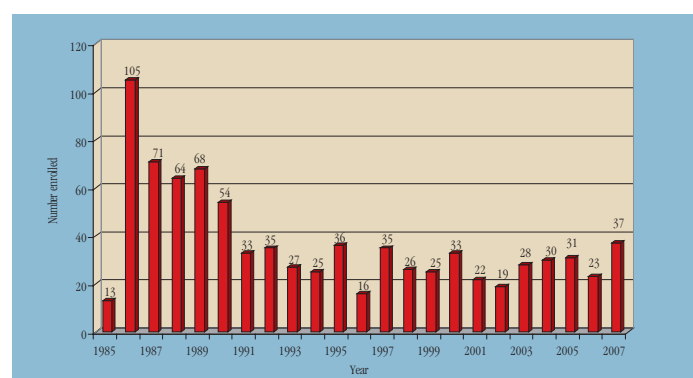
FINANCING

REVENUES JSI (€) AND NUMBER OF PROJECTS

	2006	2007	2007/2006	contrib. 2007	No. of projects in 2007
Contracts with ministries of the RS	28,581,556	29,243,094	102.31 %	72.26 %	628
Other contracts	5,640,198	5,831,586	103.39 %	14.41 %	343
International contracts	4,526,022	5,396,049	119.22 %	13.33 %	197
TOTAL	38,747,776	40,470,729	104.45 %	100.00 %	1168



POSTGRADUATES FINANCED BY ARRS*



1985-2007

*ARRS - Slovenian Research Agency

JSI UNDERGRADUATE SCHOLARSHIPS

1977-2007

Year	FMF		FKKT	FFA	FDV	BF	FE and FRI	FS	EF	FG and FERI	MF	UNG	Total
	Physics	Mathematics											
... 1982	115	38	100				50	9	3				315
1983	10	1	5				9			1			26
1984	11	3	7			1	12			1			35
1985	18	4	6			1	19			1			49
1986	16	8	4				22	2					52
1987	20	8	4				23	2					57
1988	26	7	8			1	27	1	1				71
1989	26	6	10	2		1	19	1		1			66
1990	26	5	11			2	25			1			70
1991	23	2	9	2		2	24			1			63
1992	22	3	16	1		3	17						62
1993	21	1	15	1		3	13						54
1994	7	1	8			3	6						25
1995	2		9			3	5						19
1996	2		9			3	5						19
1997	2		12			1	4			1			20
1998	1		6			1	7			1			16
1999	2		7			4	7						20
2000	1		5			3	9						18
2001	3		13			3	10						29
2002	4		20			3	10						37
2003	3		18			2	12				1		36
2004	4		17			1	15			2	1	2	42
2005	3		12		1	2	19			2		1	40
2006	2		12		1	1	17			2		2	37
2007	3		14		1	2	18			2		1	41
TOTAL	373	87	357	6	3	46	404	15	4	16	2	6	1319

FMF Faculty of Mathematics and Physics, University of Ljubljana
FKKT Faculty of Chemistry and Chemical Technology, University of Ljubljana
FFA Faculty of Pharmacy, University of Ljubljana
FDV Faculty of Social Sciences, University of Ljubljana
BF Biotechnical Faculty, University of Ljubljana
FE Faculty of Electrical Engineering, University of Ljubljana
FRI Faculty of Computer and Information Science, University of Ljubljana

FS Faculty of Mechanical Engineering, University of Ljubljana
EF Faculty of Economics, University of Ljubljana
MF Faculty of Medicine, University of Ljubljana
FG Faculty of Civil Engineering, University of Maribor
FERI Faculty of Electrical Engineering and Computer Science, University of Maribor
UNG University of Nova Gorica

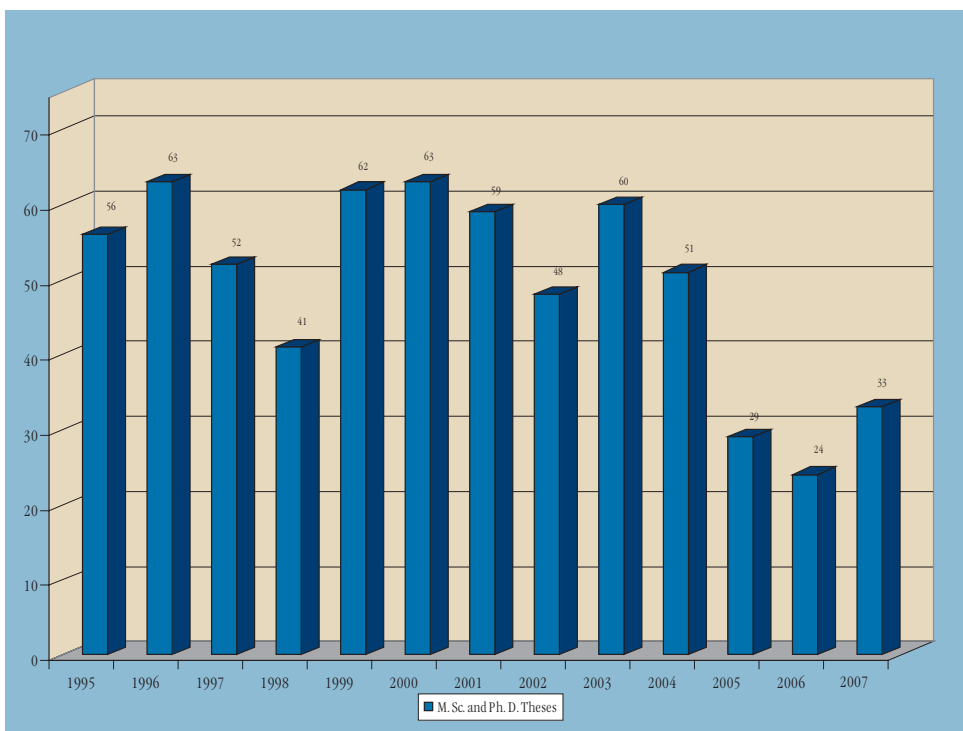
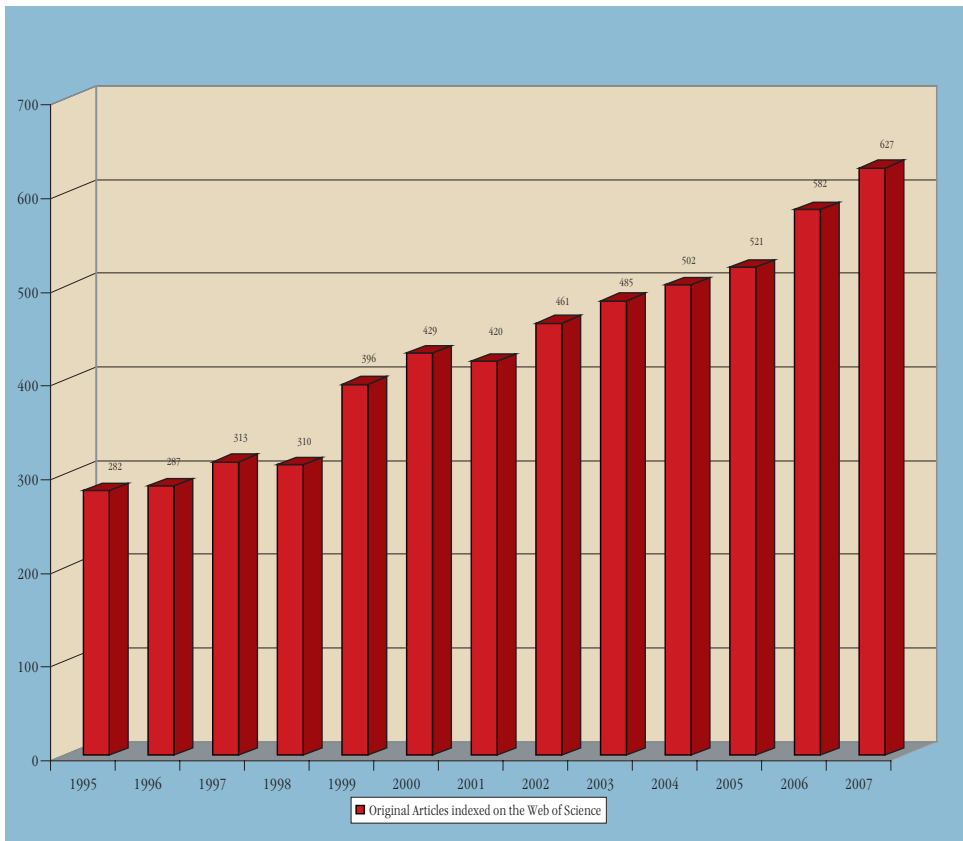
COMPLETED THESES

UNTIL 2007

Year	Ph. D. Theses	M. Sc. Theses	Total	Year	Ph. D. Theses	M. Sc. Theses	Total
...1962	15	6	21	1985	6	14	20
1963	7		7	1986	8	15	23
1964	7	2	9	1987	18	21	39
1965	16		16	1988	12	26	38
1966	2		2	1989	15	33	48
1967		8	8	1990	16	41	57
1968	4	8	12	1991	22	47	69
1969	3	6	9	1992	19	42	61
1970	2	12	14	1993	28	36	64
1971	7	6	13	1994	27	37	64
1972	11	24	35	1995	34	22	56
1973	8	14	22	1996	38	25	63
1974	21	10	31	1997	29	23	52
1975	10	20	30	1998	21	20	41
1976	6	31	37	1999	33	29	62
1977	5	16	21	2000	36	27	63
1978	10	20	30	2001	31	28	59
1979	7	11	18	2002	29	19	48
1980	13	10	23	2003	41	19	60
1981	12	15	27	2004	31	20	51
1982	13	18	31	2005	22	7	29
1983	5	10	15	2006	22	2	24
1984	14	17	31	2007	26	7	33
				TOTAL	762	824	1586

PUBLICATIONS

1995-2007



AWARDS AND APPOINTMENTS

AWARDS MADE TO JSI RESEARCHERS BY THE REPUBLIC OF SLOVENIA

Zois Recognitions and Award of the Republic of Slovenia

Prof. Ivan Bratko

Presented with the Zois Award for his outstanding achievements in artificial intelligence

Prof. Svetlana Fajfer

Presented with the Zois Award for her outstanding achievements in elementary-particle physics

Asst. Prof. Viktor V. Kabanov

Presented with the Zois Recognition for his outstanding achievements in the field of condensed matter physics

Prof. Borut Štrukelj

Presented with the Zois Recognition for his outstanding achievements in the field of pharmaceutical biotechnology

Prof. Tomaž Kosmač, Prof. Ljubo Marion, Dr. Aleš Dakskobler, Iztok Zagožen and Čedomir Oblak

Presented with the Puh award for their inventions, development achievements and the use of research findings in introducing innovations into economic practice for zirconia ceramic posts for the aesthetic fixed restoration of teeth

Prof. Igor Mekjavič, Mitja Babič, Borut Lenart, Jože Opeka, Bogomir Vrhovec

Presented with the Puh award for their achievements in R&D, and for applying the results of scientific research to industrial practice; particularly the development of a sweating thermal foot manikin with a gait simulator

JSI AWARDS AND APPOINTMENTS

Honorary Members

Prof. Robert Blinc

President of the Scientific Council from 1992 to 2007

The Jožef Stefan Golden Emblem Prize

presented to the following for doctoral theses with high impact:

Asst. Prof. Aleš Holobar, University of Maribor, Faculty of electrical engineering and computer science

Blind decomposition of convolutive mixtures of close-to-orthogonal pulse sources applied to surface electromyograms

Dr. Katja Kristan, University of Ljubljana, Faculty of Medicine

Structure/function relationship in fungal 17beta-hydroxysteroid dehydrogenase, a model enzyme of the short-chain dehydrogenase/reductase superfamily

Dr. Andrej Zorko, Jožef Stefan Institute

Study of one- and two-dimensional magnetic systems with spin-singlet ground state



The winners of the Jožef Stefan Golden Emblem Prize

INTERNATIONAL AWARDS TO JSI RESEARCHERS

Prof. Marija Kosec

Inauguration: Guest Professor of Xi'an Jiaotong University, Xi'an, China, January 22, 2007

Dr. Tadeja Kosec

1st Prize, Harvey Herro for Applied Corrosion Technology, Nashville, USA, NACE (National Association for Corrosion Technology), work "Investigation of Ni release from Nickel Silver" by Tadeja Kosec and Ingrid Milošev

Prof. Nada Lavrač

ECCAI fellow – ECCAI award. Awarded by the European Coordination Committee for Artificial Intelligence

Dr. Damir Omrčen

The article Sensorimotor Processes for Learning Object Representations was defined as one of three best articles of the conference Humanoids 2007, Pittsburgh, USA, proposer: Prof. James Kuffner

Miha Smolnikar

Best student paper award presented in the 4th WSEAS/IASME International Conference on Engineering education (EE'07), Crete Island, Greece, 24. 7. – 26. 7. 2007

Matjaž Spreitzer

Award for the best oral presentation, Herceg Novi, Montenegro, Yugoslav Materials Research Society, oral presentation: Influence of crystal symmetry on the voltage-tunability of $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ -based systems.

Matjaž Spreitzer

Award for the best paper contribution, Nara, Japan, The Committee of the 16th IEEE International Symposium on the Applications of Ferroelectrics, oral presentation: $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ -based voltage-tunable materials.

Prof. Bosiljka Tadić

Prize "Marko Jaric" for 2006, by the Fund "Marko Jaric" and the University of Belgrade for achievements in the physics of disordered and complex systems.

Prof. Boris Turk

Member of the European Molecular Biology Organisation (EMBO)

Prof. Boris Turk

Secretary General of the European Cell Death Organisation (ECDO)

Marko Viršek

Award for the Best poster, Herceg Novi, Montenegro, Yugoslav Materials Research Society (Yu-MRS)

AWARDS TO JSI RESEARCHERS BY SLOVENIAN INSTITUTIONS

Miroslav Babić

Award for young author at International Conference "Nuclear Energy for New Europe 2007", Portorož, Slovenia, organized by the Nuclear Society of Slovenia.

Prof. Robert Blinc

"Gold Medal of the IPS", Ljubljana, International Postgraduate School

Ines Bračko

Young scientists award, 15th Conference on Materials and Technology, Portorož, 8-10 October 2007, Institute of Metals and Technology, oral presentation: Understanding the formation of nanostructured perovskite CaTiO_3 under hydrothermal conditions.

Nataša Drnovšek

Young scientists award, 15th Conference on Materials and Technology, Portorož, 8-10 October 2007, in the field "Anorganic Materials": A double-layer coating on a Ti6Al4V alloy for biomedical applications.

Experimental School of Chemistry

Award from Slovenian science festival: Star of the festival (Sept 2007)

Sebastjan Glinšek

Students Prešeren Award for B. Sc. Thesis

Processing and Characterization of $\text{K}(\text{Ta}, \text{Nb})\text{O}_3$ Thin Films on Al_2O_3 Substrates

Asst. Prof. Peter Korošec

6th Trimo Research Award for doctoral thesis

Stigmergy as an approach to metaheuristic optimization

Jakob König

Young scientists award, 15th Conference on Materials and Technology, Portorož, 8-10 October 2007, Institute of Metals and Technology, oral presentation: Increasing the effect of axial pressure on the permittivity of $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ by adding NaTaO_3 .

Dr. Tomaž Langerholc

Krka Award for PhD thesis

Preparation and characterization of cystatin F and its role in antigen presentation

Miha Mihovilovič

Students Prešeren Award for B. Sc. Thesis

Tracking of unstable particles in magnetic spectrometers

Sebastijan Peljhan

Students Prešeren Award for B. Sc. Thesis, University of Ljubljana, Faculty of Chemistry and Chemical Technology

Physical and chemical study of aqueous solutions of poly(ethacrylic acid)

Katarina Rade

"Study of polymethacrylic acid in presence of various cations in aqueous media". Winning contribution of young scientists at the 15th Conference on Materials and Technologies in the field "Nanomaterials and nanotechnologies", Portorož, October 8-10 2007.

Katarina Rade

Students Prešeren Award for B. Sc. Thesis, University of Ljubljana, Faculty of Chemistry and Chemical Technology

Effect of valency of counterion on behaviour of two stereoisomers of polymethacrylic acid in aqueous solutions

Prof. Žiga Šmit

Valvasor award of honor in 2007, Slovenian Museum Society, 17. 05. 2007

Gregor Trefalt

Students Prešeren Award for B. Sc. Thesis

Preferential Adsorption of Electrolyte Mixtures in Disordered Porous Media

Prof. Vito Turk

Honorary member of the Slovene Biochemical Society

Kristina Žagar

"Synthesis and characterization of perovskite nanorods". Winning contribution of young scientists at the 15th Conference on Materials and Technologies in the field "Nanomaterials and nanotechnologies", Portorož, October 8-10 2007.



Experimental School of Chemistry on the occasion of the visit of the Minister for Education and Sport at the JSI.

REVIEW OF PUBLICATIONS

FOR 2007

Department	Original Articles*	Books	Patent Appl. and Grants	Theses
Department of Theoretical Physics (F-1)	148			1
Department of Low and Medium Energy Physics (F-2)	67		1	
Department of Thin Films and Surfaces (F-3)	22			
Department of Surface Engineering and Optoelectronics (F-4)	42		5	
Department of Solid State Physics (F-5)	118		13	1
Department for Complex Matter (F-7)	59		4	1
Department of Reactor Physics (F-8)	25	2		
Department of Experimental Particle Physics (F-9)	135			2
Department of Inorganic Chemistry and Technology (K-1)	25		3	
Department of Physical and Organic Chemistry (K-3)	23		1	1
Electronic Ceramics Department (K-5)	46		2	1
Engineering Ceramics Department (K-6)	20		1	
Department for Nanostructured Materials (K-7)	93		3	1
Department for Advanced Materials (K-9)	44		4	1
Department of Biochemistry, Molecular and Structural Biology (B-1)	36			5
Department of Molecular and Biomedical sciences (B-2)	8			
Department of Biotechnology (B-3)	33			2
Department of Environmental Sciences (O-2)	93			2
Department of Automation, Biocybernetics and Robotics (E-1)	53		2	
Department of Systems and Control (E-2)	48			3
Laboratory for Open Systems and Networks (E-5)	26			1
Department of Communication Systems (E-6)	41		1	3
Department of Computer Systems (E-7)	29		1	
Department of Knowledge Technologies (E-8)	82	4		4
Department of Intelligent Systems (E-9)	70			3
Department of Reactor Engineering (R-4)	60	1		
Energy Efficiency Centre (EEC)	16			
Milan Čopič Nuclear Training Centre (ICJT)	2			
Radiation Protection Unit (SVPIS)	5			
Technology Transfer Office (U-9)	4			1
TOTAL	1473	7	41	33

* Articles in Journals and Conference proceedings, and Chapters in books

PATENTS GRANTED

1. **Thick film piezoresistive pressure sensor with a floating diaphragm**
Marina Santo Zarnik, Darko Belavič, Marko Hrovat, Marko Pavlin
Patent No. 22106
2. **Instrument and procedure for flow detection in metallic capillary**
Zdravko Rupnik, Drago Brodnik, Matej Lipoglavšek
Patent No. 22174 A
3. **A method for hydrophobisation of a ceramic powder by applying an organic coating in an aqueous suspension**
Saša Novak, Katja König, Stojana Veskovič Bukudur
Patent No. 22211
4. **High-Speed Continually-Aligning Divider**
Rainer Trummer, Roman Trobec
Patent No. 22218
5. **Method and device for selective etching of composite materials by laser ablation**
Uroš Cvelbar, Miran Mozetič, Slobodan Milošević, Nikša Krstulović
Patent No. 22288
6. **Instrument for flow measurement of fluids with more ranges**
Alessandro Lukan
Patent No. 22314
7. **Procedure and optical device for image showing visible from every direction**
Leon Lahajnar, Janez Leskovec, Franci Lahajnar
Patent No. 22319 (application 200600122)
8. **New arylsulfonohydrazide inhibitors of enzymes MurC and MurD**
Aleš Obreza, Rok Frlan, Nina Vobovnik, Andreja Kovač, Didier Blanot, Slavko Pečar, Stanislav Gobec
Patent No. EP1845083
9. **Keramisches Material, gesinterte Keramik und Bauelement daraus, Verfahren zur Herstellung und Verwendung der Keramik**
Pavol Dudešek, Bad Gams, Christian Hoffmann, Danilo Suvorov, Matjaž Valant
Patent no. DE 102006024231A1
10. **Elektrisches Bauelement und dessen Herstellung**
Matjaž Valant, Florian Heinz, Bad Gams, Klaus Reichmann, Danilo Suvorov
Patent no. DE 10325008.5
11. **Composite microwave dielectric material based on magnesium titanate and calcium titanate**
Bilous Anatoli Grigorovič, Oleg V. Ovchar, Durilin Dmitro Oleksandrovič, Marjeta Maček-Kržmanc, Matjaž Valant, Danilo Suvorov
Patent no. UA 78081
12. **A new way of learning about objects for visual recognition by manipulation**
Aleš Ude, Gordon Cheng, Kai Welke, Joshua G. Hale
Patent no. Japan 2007-096733



Photograph of coated and uncoated Al_2O_3 powder in a petri dish with water. In contrast to the uncoated powder, which is easily wetted, the coated powder (at pH 10.9) floats on the water's surface.



Low-pressure injection-molded cones (on the left) and needles (on the right) from paraffin suspensions of coated alumina at pH 10.4, before (upper line) and after (bottom line) the addition of water. In spite of water being added to the suspension of coated powder, the rheological properties remained suitable for low-pressure injection molding, moreover, the quality of injection-molded parts remained unchanged.

CENTRES OF EXCELLENCE

Research Centres of Excellence, a concept developed by the Ministry of Higher Education, Science and Technology and co-financed by the European Regional Development Fund, are a new form of cooperation between research institutes, academic institutions, and industry. Their main goal is the development of an innovative environment to facilitate the transfer, management, and development of new technologies in various priority areas of research and technology. For the period 2004-2006, the Jožef Stefan Institute has been chosen as the coordinator of four Centres of Excellence, with twenty R&D projects.

Nanoscience and Nanotechnology

Head: Prof. Dragan Dragoljub Mihailović

Project Activity Group (projects are partly cofunded by European Union):

1. Project for encouraging innovation, Measure 1.1.

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partner: LPFK, d.o.o., Zgornje Jezersko; Belinka Belles, d.o.o., Ljubljana; Iskra Feriti, d.o.o., Ljubljana; Keko Oprema, d.o.o., Žužemberk; MS Production, Bled; Iskra Mehanizmi, d.d., Kropa; Lek, d.d., Ljubljana; Acroni, d.o.o., Jesenice; Iskra Kondenzatorji, d.d., Semič; Eta Cerčno, d.o.o., Cerčno; Steklarna Hrastnik, d.d., Hrastnik; Steklarna Rogaška, d.d., Rogaška Slatina; HYB, d.o.o., Šentjernej; Balder, d.o.o., Ljubljana; Cinkarna Celje, d.d., Celje; AET, d.o.o., Tolmin; Kolektor Pro, d.o.o., Idrija; Atotech, d.d., Podnart; Iskra Tela, d.d., Ljubljana; Predilnica Litija, d.o.o., Litija; Termo, d.d., Škofja Loka; Mo6, d.o.o., Ljubljana; National Institute of Chemistry, Ljubljana

2. Synthesis of 1D Inorganic Nanostructures, Bionanostructures and Preparation of Composites

Project leader: Aleš Mrzel

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partner: Termo, d.d., Škofja Loka; Mo6, d.o.o., Ljubljana

3. Nanomaterials in Electrochemical Systems

Project leader: Janez Jamnik

Leading institution: National Institute of Chemistry, Ljubljana

Cooperating partner: Atotech, d.d., Podnart; Iskra Tela, d.d., Ljubljana; Predilnica Litija, d.o.o., Litija; Jozef Stefan, Ljubljana; University of Ljubljana, Faculty of chemistry, Ljubljana; University of Maribor, Faculty of mechanical engineering, Maribor

4. Nanostructured Surfaces and Interfaces

Project leader: Igor Muševič

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partner: HYB, d.o.o., Šentjernej; Balder, d.o.o., Ljubljana; Cinkarna Celje, d.d., Celje; AET, d.o.o., Tolmin; Kolektor Pro, d.o.o., Idrija; HIPOT-RR, d.o.o., Šentjernej; University of Nova Gorica, Nova Gorica

5. Characterisation on a Nanometric Scale

Project leader: Miran Čeh

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partner: Lek, d.d., Ljubljana; Acroni, d.o.o., Jesenice; Iskra Kondenzatorji, d.d., Semič; Eta Cerčno, d.o.o., Cerčno; Steklarna Hrastnik, d.d., Hrastnik; Steklarna Rogaška, d.d., Rogaška Slatina; Institute of Metals Tehnology, Ljubljana; National Institute of Chemistry, Ljubljana

6. Synthesis of Nanoparticles and Nanocomposites

Project leader: Darko Makovec

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partner: Belinka Belles, d.o.o., Ljubljana; Institute of Metals and

Technology, Ljubljana; National Institute of Chemistry, Ljubljana; Keko Oprema, d.o.o., Žužemberk; MS Production, Bled; Iskra Mehanizmi, d.d., Kropa; KOLEKTOR MAGMA, d.o.o., Ljubljana

7. Nanoelectronics and Nanotechnology Facilities

Project leader: Dragan Mihailović

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partner: LPKF Laser & Elektronika, d.o.o., Zgornje Jezersko; University of Nova Gorica

8. The Development of the Research Infrastructure of The Center of Excellence and Nanotechnology (CE NS and NT), Measure 1.4.

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partner: LPKF Laser & Elektronika, d.o.o., Zgornje Jezersko; National Institute of Chemistry, Ljubljana

Materials for Electronics of Next Generation and Other Emerging Technologies

Head: Prof. Marija Kosec

Project Activity Group:

1. Magnetic Materials and Intermetallic Alloys

Project leader: Spomenka Kobe

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partners: Institute of Metals and Technology, Ljubljana; Magneti, d. d., Ljubljana; Kolektor Magma, d. o. o., Ljubljana; Kolektor, d.o.o., Idrija.

2. Microstructures and Microsystems

Leading institution: University of Ljubljana, Faculty of Electrical Engineering, Ljubljana

Cooperating partners: Iskra Tela, d. d., Ljubljana; Iskra Avtoelektrika, d. d., Nova Gorica

3. New generation of Elements and Devices for Protection Against Transient Surges

Project leader: Slavko Bernik

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partners: Milan Vidmar Electric Power Research Institute, Ljubljana; Zavod TC SEMTO, Ljubljana; VARSİ, d. o. o., Ljubljana; Iskra Zaščite, d. o. o., Ljubljana; University of Ljubljana, Faculty of Electrical Engineering, Ljubljana; Iskra Tela, d. d., Ljubljana

4. Hybrid Materials and Structures

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partners: HIPOT-RR, d. o. o., Šentjernej; HYB, d. o. o., Šentjernej

5. Complex Materials for New Technologies: From Soft Matter to Hard Coatings

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partners: Gorenje, d. d., Velenje; Balder, d. o. o., Ljubljana; University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana; Institute for Mathematics, Physics and Mechanics in Ljubljana, Laboratory for NQR and weak magnetic fields, Ljubljana

Environmental Technologies

Head: Prof. Milena Horvat

Project Activity Group:

1. Biological Methods of Wastewater Treatment

Leading institution: University of Ljubljana, Faculty of Civil Engineering and Geodesy, Ljubljana

Cooperating partners: University of Ljubljana, Biotechnical Faculty; University of Ljubljana, Faculty of Medicine; University of Nova Gorica; National Institute of Biology, Ljubljana; Inštitut za varstvo, d.o.o., Ljubljana; National Institute of Chemistry, Ljubljana; Komunalno podjetje Velenje, d. o. o., Velenje; Esotech, d. d., Velenje; RACI d.o.o., Ljubljana; LIMNOS – Company for Applied Ecology, d. o. o., Ljubljana; Lek farmacevtska družba d.d., Ljubljana, Fructal živilska industrija d.d., Ajdovščina; Javno podjetje Okolje Piran, d.o.o., Piran; Helios Domžale d.d., Domžale; Euroinvest, d.o.o., Nova Gorica; Salonit Anhovo gradbeni materiali, d.d., Anhovo; Cinkarna Celje, d.d., Celje.

2. Ecoremediation Technologies

Leading institution: University of Ljubljana, Biotechnical faculty, Ljubljana

Cooperating partners: Institute of Physical Biology, Grosuplje; University of Ljubljana ; Slovenian Forestry Institute, Ljubljana; GSF – National Research Center for Environment and Health, Institut for Soil Ecology, Neuherberg, Germany; Community of Celje, Celje; ERICO, Environmental Research & Industrial Co-operation Institute, Velenje; Limnos – Company for Applied Ecology, d. o. o., Ljubljana, Nuclear Power Plant Krško, d.o.o., Krško; PV Invest, d.o.o., Velenje; Javno komunalno podjetje Cankova, d.o.o., Cankova; Komunalno podjetje Velenje, d. o. o., Velenje; Javno podjetje Centralna čistilna naprava Domžale-Kamnik, d.o.o., Domžale;

3. Recycling and Use of Waste

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partners: University of Maribor, Faculty of Chemistry, Maribor; Esotech, d. d., Velenje; National Institute of Biology, Ljubljana; Domžale – Kamnik Wastewater Treatment Plant, d. o. o., Domžale; National Institute of Chemistry, Ljubljana; TKI Hrastnik, d.d., Hrastnik; TANIN Sevnica, Industry of Chemistry, d.d., Sevnica, Radenska d.d., Radenci.



Advanced Control Technologies

Head: Prof. Stanko Strmčnik

Project Activity Group:

1. Advanced Control Methods

Leading institution: University of Ljubljana, Faculty of Electrical Engineering, Ljubljana

Cooperating Partners: Jožef Stefan Institute, Ljubljana; Robotina d.o.o., Koper; Metronik, d.o.o., Ljubljana; Liko Pris, d.o.o., Vrhnika; Lek, d.d., Ljubljana; Domžale – Kamnik Wastewater Treatment Plant, d.o.o., Domžale

2. Automatic On-line Supervision of Processes and Product Quality Control

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partners: Domel, d.d., Železniki; Telem, d.o.o., Maribor; FDS Research, d.o.o., Trzin;

3. Technologies of Distant and Distributed Control

Leading institution: University of Maribor, Faculty of Electrical Engineering and Computer Science, Maribor

Cooperating partners: Jožef Stefan Institute, Ljubljana; University of Ljubljana, Faculty of Electrical Engineering, Ljubljana; Inea, d. o. o., Ljubljana; Špica International, d. o. o., Ljubljana; Telem, d. o. o., Maribor

4. Decision Support for Control in Production

Leading institution: Jožef Stefan Institute, Ljubljana

Cooperating partners: University of Ljubljana, Faculty of Electrical Engineering, Ljubljana; University of Maribor, Faculty of Electrical Engineering and Computer Science, Maribor; Inea, d. o. o., Ljubljana; Metronik, d. o. o., Ljubljana; Synatec, d. o. o., Idrija.

5. Product Information Management through Complete Lifecycle

Leading institution: University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana

Cooperating partners: Domel, d. d., Železniki; Alpina, d. d., Žiri

6. Project Control in System of Orders

Leading institution: University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana

Cooperating partners: Eti Elektroelement, d. d., Izlake; Liv Plastika, d. o. o., Postojna

Transmission electron microscopy and scanning electron microscopy are the base for the exploration of the micro- and nanoworld. Their resolution enables us to detect small nanoparticles, molecules and even atoms. Moreover, we can determine directly the structure and the relations between building blocks. X-ray and electronic spectroscopy give us the power to identify small groups of atoms and their crystalline structure. Also, in-situ experiments can be carried out with these instruments, with real-time observation possibilities. This is a great advantage compared with other experimental methods since the measured systems can be monitored directly.

KNOWLEDGE TRANSFER

In 2007 the JSI paid a lot of attention to furthering its links with industry. Studies clearly show that both Europe and Slovenia are among the leaders in research worldwide. On the other hand, the transfer of knowledge to enterprises and industry is not as efficient as in, for example, the USA. Therefore, European commissioners state publicly that such cooperation should be encouraged and intensified. In keeping with European aims and the objectives of the Slovenian government, the JSI organized several important meetings on the subject of cooperation with enterprises and industry. In this way the JSI introduced a new method of cooperation, showing industry and the public that it is aware of its leading role, not only in research but also in the transfer of knowledge into practice.

A result of this growing attention to knowledge transfer is the signing of more than 250 R&D contracts in 2007.

R & D PROJECT PARTNERS

1. AET, d. o. o., Tolmin
2. Agency for Radwaste Management, Ljubljana
3. Agricultural Institute of Slovenia, Ljubljana
4. AMEBIS, d. o. o., Kamnik
5. AMES, d. o. o., Ljubljana
6. ATR Computational Neuroscience Laboratories, Kyoto, Japan
7. Balder, d. o. o., Ljubljana
8. B-Cat BV, Tiel, The Netherlands
9. Bekleidungsphysiologisches Institut Hohenstein, Boennigheim, Germany
10. Calcit, d. o. o., Stahovica
11. Cinkarna Celje, d. d., Celje
12. Cmepius, Ljubljana
13. CNRS Centre d' Etudes de Physiologie Appliquee, Strasbourg cedex, France
14. Computel, d. o. o., Ljubljana
15. Cosylab, laboratorij za kontrolne sisteme, d. d., Ljubljana
16. Danfoss Trata, d. o. o., Ljubljana Šentvid
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38. Heraklith Consulting & Engineering GmbH, Ferndorf, Austria
39. Hidria AET, d. o. o., Tolmin
40. Hipot - RR, d. o. o., Šentjernej
41. HSE Invest, d. o. o., Maribor
42. HYB Proizvodnja hibridnih vezij, d. o. o., Šentjernej
43. Ilirija, d. d., Ljubljana
44. Induktio, d. o. o., Ljubljana
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47. Iskra Avtoelektrika, d. d., Šempeter pri Gorici
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49. Iskra ISD, d. d., Kranj
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51. Iskra TELA, d. d., Ljubljana
52. Iskra Zaščite, d. o. o., Ljubljana
53. Istrabenz plini, Plini in plinske tehnologije, d. o. o., Koper
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89. Municipality of Ljubljana, Ljubljana
90. Municipality of Maribor, Maribor
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92. National Centre of Scientific Research "DEMOKRITOS", Aghia Paraskevi, Athens, Greece
93. National Institute of Chemistry, Ljubljana
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125. Synatec, d. o. o., Idrija
126. Štore Steel, d. o. o., Štore
127. Technology Park Ljubljana, d. o. o., Ljubljana
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137. University of Maribor, Maribor
138. University of Nova Gorica, Nova Gorica
139. Univerza na Primorskem, Koper
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143. Vip - Virant, d. o. o., Ljubljana
144. VLS computers, d. o. o., Velenje
145. Xella Porobeton si, d. o. o., Kisovec
146. Xerox Slovenija, d. o. o., Ljubljana
147. Združenje zdravstvenih zavodov, Ljubljana
148. Žito Šumi, d. o. o., Ljubljana



Engineers from the Kolektor company visiting the Robotics laboratory of the Department of Automation, Biocybernetics and Robotics.

RESEARCH DEPARTMENTS

DEPARTMENT OF THEORETICAL PHYSICS

F-1

The research program of the Department of Theoretical Physics is focused on the theory of condensed-matter physics, statistical physics, the physics of nuclei, particles and fields, as well as biophysics and soft condensed-matter physics. The department also maintains its own high-performance computing facility, for which it develops the necessary software. These studies are carried out in close collaboration with several experimental groups at the Jozef Stefan Institute as well as with local and foreign universities and institutes. The department is also involved in various international projects.

The group of Theoretical Physics of Nuclei, Particles and Fields has investigated the structure of hadrons, the effective theories of weak and electromagnetic mesonic decays, the unified theory of elementary interactions, the relativistic theory of membranes and precise calculations of the properties of three-body systems in atomic physics.



Head:
Prof. Svjetlana Fajfer

We have succeeded in finding a stable solitonic solution corresponding to the nucleon in the framework of the spectral quark model in which the valence quarks never become unbound. We have shown that the model yields reasonable predictions for the static observables of the nucleon.

We determined the spectra of ground and excited mesons using a large variety of interpolating fields with various orbital quantum numbers L . We simulated light scalar mesons on the dynamical lattice using the so-called staggered quarks. Using analytical methods we successfully explained the non-physical effects of staggered formalism on the lattice data.

We have investigated the possibilities to obtain signals of new physics in rare charm meson decay to a leptonic pair. We have continued our research on chiral corrections to processes of heavy mesons by studying the weak transitions among B and D mesons of both parities. We have confirmed that the mixed contributions (due to loops containing opposite parity heavy states compared to external states) do not spoil the chiral limit of the amplitudes and have provided the leading extrapolation formulae to guide lattice QCD simulation results towards the physical limit. We have studied the mass and flavour structure of the 'Littlest Higgs' model and have pointed out some weaknesses in the existing studies of this model. We have derived predictions for deviations from CKM unitarity as well as for flavour changing neutral currents in the up-quark sector at tree level. Based on existing experimental constraints on the model parameters we have given predictions for some rare processes of D mesons and the top quark.

We have shown that the effect of decay width can be appreciable in gamma extraction from neutral B decays. We have discussed the prospect of observing minimal flavour violation in high pT processes at the LHC. We have completed work on semi-inclusive hadronic decays so that now all the modes including isosinglets have been calculated at leading order. We have shown that new BaBar and Belle measurements in $B \rightarrow K^* \pi$ decays already provide enough information to have a constraint on the CKM weak phase at one sigma.

We studied the minimal nonsupersymmetric $SU(5)$ model adding a fermionic adjoint representation. This solves all the usual problems connected with the unification constraints and neutrino masses. The model predicts light, fermionic, weak triplets that may be found at the LHC, the decays of which are connected to neutrino masses and mixings.

We have studied the dynamics of relativistic branes in 16-dimensional Clifford space. The action for such a system contains terms which may be interpreted as the couplings of a brane with various 4-dimensional Yang-Mills gauge fields, including gravitational ones.

Starting from the CFHM method we studied analytic approximations of three-body wave functions of systems bound by the Coulomb interaction, for example, the Helium atom. As opposed to many expressions in the literature

We found a simple example of a predictive $SU(5)$ grand unified theory.

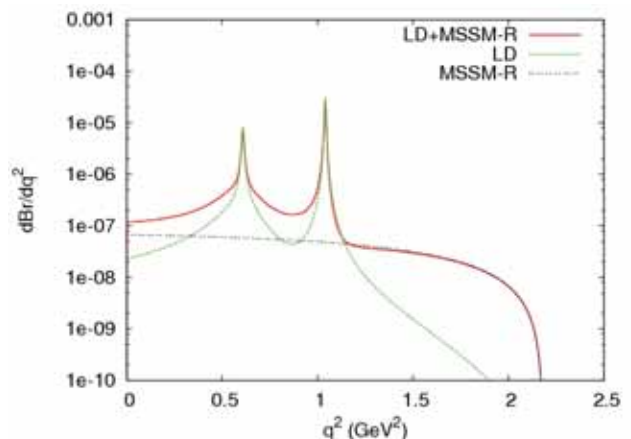


Figure 1: Energy spectrum of electron-positron pair in the decay $D_s^+ \rightarrow K^+ e^+ e^-$. The R -parity violating minimal supersymmetric standard model (red) enhances the non-resonant part of the spectrum by at least one order of magnitude with respect to the standard model (green). Article: Fajfer, Svjetlana, Košnik, Nejc, Prelovšek, Saša, Updated constraints on new physics in rare charm decays. Phys. rev., D Part. fields gravit. cosmol., 76, 074010 (2007).

we limited ourselves to the regions near the coalescence points. Our accurate numerical solution of the three-body Schrödinger equation was used for comparison. The results are useful for estimating ionization processes.

The group for Solid State Theory and Statistical Physics has been investigating critical phenomena in ferroelectrics and self-organised structures, the properties of electronic nanosystems as well as strongly correlated electrons in novel materials.

The modelling of the dynamic processes on networks offers theoretically interesting concepts for a quantitative analysis of complex dynamical systems, on the one hand, and possibilities for the reversed engineering of functional materials and their dynamical stability, on the other.

A new physical mechanism for the freezing of dielectric polarization in relaxor ferroelectrics and related materials has been proposed. The relaxation time diverges as the volume reaches the percolation limit, and its temperature dependence is found to obey the empirical Vogel-Fulcher relation. Within the model of transport on networks we have developed a model for charge transport with single-electron tunnelings through self-assembled nano-particle arrays, modelled with planar graphs with varying connectivity. The results of numerical simulations for nonlinear characteristics on different nano-structures are compared with the experimental measurements in nano-particle films, in collaboration with

a group from the University of Nottingham. In coupled two-dimensional chaotic maps on networks we have studied dynamical stability and the collective dynamical effect

Investigations of the spectral functions of hole- and electron-doped high-Tc cuprates have been continued. With the Lanczos method upgraded with a gauge phase it has been shown that the Fermi surface upon doping develops from a pocket-like and arc-like into a large connected surface, as established in ARPES experiments. The phenomenon of large-energy kink and ‘waterfall’ has been reproduced and attributed to strong correlations. The validity of the Luttinger theorem for the Fermi volume has been investigated, and it has been shown to be valid in principle also for finite systems, nevertheless violated within the planar t-J model and the Hubbard model on a triangular lattice. The magnetic spin response of cuprates has been further studied in connection with neutron-scattering experiments. An efficient numerical method for the description of a single-hole motion in the antiferromagnetic background has also been developed. A systematic increase of the variational functional space led to results that are valid in the thermodynamic limit. The method allows a straightforward addition of other inelastic degrees of freedom, such as lattice effects. The results confirm the existence of a finite quasiparticle weight near the band minimum. We also investigated the ESR measurements performed on an α - NaMnO_2 polycrystalline sample and modelled a quantum spin-2 system on a frustrated triangular lattice.

The effect of electron hopping in a triple quantum dot has been studied. We have determined the range of parameters where the system exhibits the two-channel Kondo effect and non-Fermi-liquid behaviour, as probed via the differential conductance. We also investigated the low-temperature transport properties of the systems of parallel quantum dots described by the N-impurity Anderson model. We investigated the structural, mechanical, electronic and optical properties of molybdenum-chalcogenide nanowires, and compared the results with experiments performed in the Department of Complex Matter. We showed that the temperature and magnetic-field properties of the entanglement between qubit pairs on the two-dimensional Shastry-Sutherland lattice can be qualitatively described by analytical results for a qubit tetramer. We presented and discussed different regimes of quantum dots coupled to external leads. An analysis of charge rearrangement and screening in quantum point contacts has also been performed.

We have studied the electrostatic interactions between dielectrically inhomogeneous media within the weak and strong coupling framework. We have evaluated the van der Waals forces between nanotubes and we have demonstrated the equality of the density functional and field theory approaches to treat the van der Waals

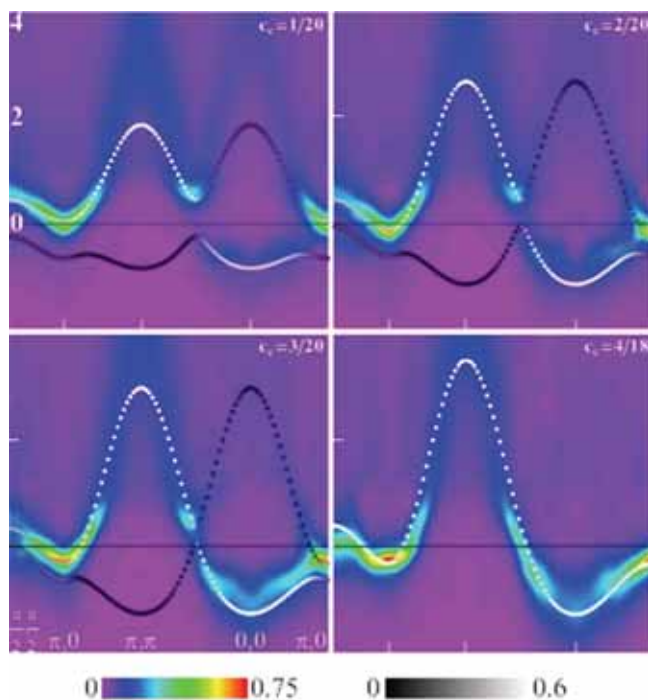


Figure 2: Colour weight map showing spectral functions of the t-J model at different doping concentrations, obtained via the numerical finite-temperature Lanczos method. The spectra correspond to experiments performed on electron-doped cuprates.

The group of Theoretical Biophysics and Soft Matter Physics focused on polyelectrolytes, liquid crystals, colloids, and phospholipid and biological membranes

We have studied the electrostatic interactions between dielectrically inhomogeneous media within the weak and strong coupling framework. We have evaluated the van der Waals forces between nanotubes and we have demonstrated the equality of the density functional and field theory approaches to treat the van der Waals

interactions. We have measured and explained the frequency dependence of the dielectric function in aqueous solutions of DNA molecules and obtained the scaling laws for the characteristic length scales of relaxation. We have also studied the effect of the electrostatic interactions on the self-assembly of empty viral capsids.

We have explored the ordered states of spatially confined superparamagnetic colloids and shown that due to the soft interactions at small colloid-colloid separations the phase behaviour becomes very rich. In addition to the typical hexagonal structure, the square, labyrinthine and honey-comb lattices have been observed.

We have also analyzed the structure of aggregates of lipid vesicles. We have explored the possible scenarios for the formation of small aggregates of three-dimensional vesicles as model erythrocytes and we have found that the characteristic long linear aggregates called rouleaux are formed only at moderate adhesion strengths. We have studied the topology and size of two-dimensional vesicles, which turn out to be infinite and either linear or sheet-like. We have investigated the prolate-to-oblate shape transition in phospholipid vesicles in response to the frequency variation of an alternate electric field and explained it by the dielectric anisotropy of a phospholipid bilayer. A comprehensive study was made on the involvement of membrane hydraulic and solute permeabilities in the process of vesicle self-reproduction.

We have studied the regulatory impact of light-chain myosin kinase and phosphatase on the calcium signal transduction pathway in the process of force development in airway smooth muscles and applied the results of this analysis in discussing some clinical cases of asthma diseases.

In the field of liquid crystals we have theoretically studied chiral interlayer interactions in bent-core systems and incommensurate phases in antiferroelectric liquid crystals.

Aggregates of two-dimensional vesicles can be either linear or sheet-like. The spatially confined magnetic particles interact via a purely repulsive interaction, yet they form chain-like structures.

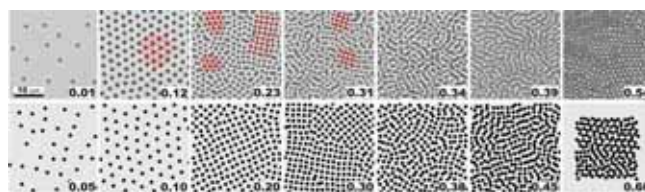


Figure 3: Sequence of ground states of core-softened colloids: Experimentally observed (above) and numerically simulated (below) phases of quasi two-dimensional superparamagnetic colloids; N. Osterman, D. Babić, I. Poberaj, J. Dobnikar, and P. Zihnerl, *Phys. Rev. Lett.* 99, 248301 (2007).

Some outstanding publications in the past three years

Theoretical Physics of Nuclei, Particles and Fields

1. A. R. Williamson and J. Zupan, Two body decays with isosinglet final states in SCET, *Phys. Rev. D* 74, 014003 (2006).
2. B. Bajc and G. Senjanović, Radiative seesaw: A case for split supersymmetry, *Phys. Lett. B* 610, 80 (2005).

Solid State Theory and Statistical Physics

1. R. Žitko and J. Bonča, Fermi liquid versus non-fermi-liquid behavior in triple quantum dots, *Physical Review Letters*, 98, 047203 (2007).
2. T. Rejec and Y. Meir, Magnetic impurity formation in quantum point contacts, *Nature* 442, 900 (2006).

Theoretical Biophysics and Soft Matter Physics

1. P. Zihnerl and S. Svetina; Flat and sigmoidally curved contact zones in vesicle-vesicle adhesion, *Proc. Natl. Acad. Sci. USA*. 104 (3), 761 (2007).
2. N. Osterman and D. Babić and I. Poberaj and J. Dobnikar and P. Zihnerl; Observation of Condensed Phases of Quasiplanar Core-Softened Colloids, *Phys. Rev. Lett.* 99, 248301 (2007).

Awards and appointments

1. Prof. Svjetlana Fajfer: Zois award for the highest scientific achievements in the area of elementary particle physics
2. Prof. Bosiljka Tadić: Prize "Marko Jaric" for 2006, by the Fund "Marko Jaric" and the University of Belgrade for achievements in the physics of disordered and complex systems.

Organization of conferences, congresses and meetings

1. Physical fundamentals of nanoelectronics, Portorož, Slovenia 2. 9.-7. 9. 2007
2. Hadron Structure and Lattice QCD, Bled, Slovenia 9. 7.-16. 7. 2007

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THESES

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2. Rok Žitko
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B. Sc. Theses

1. Ana Hočvar: Structure of sheet-like aggregates of lipid vesicles (Assist. Prof. Primož Zihel)
2. Lev Vidmar: Dynamical properties of underdoped antiferromagnets (Prof. Janez Bonča)

INTERNATIONAL PROJECTS

1. Minimal Grand Unified Theory
MUST
Marie Curie
6. FP; MIF1-CT-2006-040907
EC
Asst. Prof. Borut Bajc

2. Novel Magnetic-mode Heat Transport for Thermal Management in Microelectronics
NOVMAG, 6. FP; 032980
EC; Dr. Christian Hess, Leibniz Institute for Solid State and Materials Research Dresden, Institute for Solid State Research, Dresden, Germany
Prof. Peter Prelovšek
3. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries
MULTICERAM
6. FP; NMP3-CT-2006-032616
EC; Prof. Andrei Kholkin, University of Aveiro, Dept. of Ceramics & Glass Engineering, Aveiro, Portugal
Prof. Raša Pirc, Prof. Robert Blinc, Prof. Marija Kosec, Dr. Janez Holc

4. Many-body Interactions in Charged Colloidal Suspensions
Many-body Colloids
MERC-CT-2005-031089, 6. FP
EC
Dr. Jure Dobnikar
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EC; Lancaster University, Lancaster, Great Britain
Prof. Anton Ramšak
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EC; The University of Nottingham, Nottingham, Great Britain
Prof. Bosiljka Tadić
7. Emergent Behaviour in Correlated Matter
COST P16
EC
Prof. Peter Prelovšek
8. Physics of Risk
COST P10
EC
Prof. Bosiljka Tadić
9. Nucleon in the Spektral Quark Model
BI-PL/05-07-008
Prof. Broniowski Wojciech, Instytut Fizyki Jadrowej, Krakow, Poland
Prof. Bojan Golli
10. Nucleon Resonances in Chiral Models
BI-PT/06-07-010

- Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
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11. Electronic Properties of Quantum Dots and Nanodevices
BI-UA/07-08-006
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 12. Novel Phases of Correlated Electron Systems
BI-US/06-07-010
Dr. James Gubernatis, Los Alamos National Laboratory, Los Alamos, USA
Prof. Janez Bonča

R & D GRANTS AND CONTRACTS

1. High performance computing algorithms in theoretical physics
Dr. Rajmund Krivec
2. Quantum many-body dynamics in nanostructures and quantum information
Dr. Kristjan Haule
3. Novel ground states of frustrated spin systems under doping
Dr. Samir El Shawish

RESEARCH PROGRAMS

1. Theory of condensed matter and statistical physics
Prof. Dr. Janez Bonča
2. Biophysics of polymers, membranes, gels, colloids and cells
Prof. Dr. Rudolf Podgornik
3. Theoretical physics of nuclei, particles and fields
Prof. Dr. Svjetlana Fajfer

VISITORS FROM ABROAD

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2. Prof. Jan Eeg, Physics Department, Oslo University, Oslo, Norway, 8. 1. - 26. 1. 2007
3. Dr. Jan O. Haerter, Physics Department, University of California, Santa Cruz, USA, 29. 3. - 2. 4. 2007
4. Dr. Hrvoje Štefančić, Institute Ruder Bošković, Zagreb, Croatia, 30. 5. - 1. 6. 2007
5. Prof. Victor Mandelzweig, Racah Institute of Physics, Hebrew University, Jerusalem, Israel, 31. 5. - 30. 6. 2007
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10. Dr. Marko Djordjević, Mathematical Biosciences Institute, The Ohio State University, Ohio, USA, 31. 8. 2007
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18. Dr. Christos N. Likos, Heinrich-Heine Universität Düsseldorf, Düsseldorf, Germany, 13. 10. 17. 10. 2007
19. Dr. Julia Fornleitner, Institut für Theoretische Physik, Vienna, Austria, 10. 11. - 17. 11. 2007
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DEPARTMENT OF LOW AND MEDIUM ENERGY PHYSICS

F-2

The F-2 Department conducts basic and applied research in low- and medium-energy physics. Low-energy physics accounts for our atomic physics research, while the part of nuclear physics studied at the department can be classified as intermediate-energy physics. The third research field of the department is radiological environmental protection, which involves monitoring nuclear objects and environmental radioactivity. The department also operates the Ecological Laboratory with a Mobile Unit as a specialized Civil Protection unit.



Head:
Asst. Prof. Matej Lipoglavšek

Fundamental research in nuclear physics is performed by the Structure of Hadronic Systems Group. In the A1 Collaboration at MAMI (Mainz, Germany) we have performed the second part of precise proton elastic form-factors measurements at low momentum transfers, where various physical observables are most sensitive to the meson cloud. To separate the electric and magnetic form-factors, we do not apply the Rosenbluth technique, but rather a fit of the data measured on an extensive kinematics grid to a phenomenological formula. We have also performed new measurements of the neutron electric form-factor at high momentum transfers. In addition, we have embarked on a unique program to use triple-polarization observables to investigate certain aspects of the spin structure of the He-3 nucleus. To this end, we use polarized electrons, a polarized target, and measure the polarization of the outgoing protons.

In the Hall A Collaboration at the Jefferson Laboratory, we performed a measurement of single-nucleon knockout from PB-208 nuclei, for various discrete states of the residual nucleus and in a broad range of missing momenta. Through measurements of the transverse-longitudinal asymmetries we are trying to determine the dynamic role that the lower components of Dirac spinors play in the nucleus, and thereby evaluate the importance of the relativistic mechanisms for the structure of heavy nuclei. We have also started a series of experiments devoted to the precision measurement of the Coulomb sum rule for various (light and heavy) nuclei. In spite of years of extensive research, the Coulomb sum rule has not yet been unambiguously proven. Within the Hall C Collaboration, we have initiated a time-consuming experimental program aimed at determining the ratio of the electric and magnetic form-factors of the proton at very high momentum transfers (up to about 10 GeV^2). This quantity can be obtained from the ratio of two polarization components of the elastically recoiled proton with minimum systematic uncertainty. At the same time, we hope to be able to evaluate the relevance of the two-photon contributions to the elastic scattering process, in which polarization, according to most recent theoretical work, plays a non-trivial role.

In 2007 our research in the field of gamma-ray spectrometry was conceived and carried out with an emphasis on the practical use of its results in our routine measurements. We first checked the reliability of our procedure for the analysis of HPGE spectra for activities of radionuclides close to the detection limit. We also continued the development of an entirely new approach to spectrum analysis, based on full-spectrum matching by a linear combination of the synthetic spectra created from the nuclear-decay data contained in a context-sensitive library. The approach was successfully verified experimentally in collaboration with our German colleagues from the Physikalisch-Technische Bundesanstalt (PTB), the German national metrological institute. In collaboration with the PTB we also started research into the determination of the half-life of Lu-176, a radionuclide that is important in geochronological studies, which we intend to tackle by applying the sum-peak method to spectrometric measurements. We also conducted a study of the optimum sampling times, sample preparation techniques and measurement procedures for water samples that guarantees the lowest possible detection limit. In collaboration with several research institutions around the globe we coordinated and carried out an intercomparison study on the use of Monte Carlo simulation methods in environmental gamma-ray spectrometry, the results of which should provide general guidelines for the intrinsic uncertainty of this approach and lead to unified ways of its application.

Work in the low-energy physics part of the F2 department was mainly driven by the research programme "Study of atoms, molecules and structures with photons and particles" and two projects that are running under the umbrella of the Slovenian Fusion Association (EUROATOM-MHEST). Basic and applied research was performed at home, mainly at the Microanalytical Infrastructure Center (MIC) and abroad, most frequently at different synchrotron laboratories in Europe, where we have conducted research on our own projects and did some collaborative work, too. Our main achievements in 2007 are:

- a theoretical treatment of the helium atom in strong and homogeneous dc electric fields and its response to photoexcitation. A method of complex rotation was used for this purpose. The same was used for the modelling of the inelastic photon scattering on doubly excited states in a zero field environment - the corresponding experiment was conducted by the group from Uppsala University at the synchrotron BESSY (Germany).

- Electron spectrometry was dealt with in the frame of the Slovenia-Hungary bilateral project in collaboration with the group of prof. Paripas from the Physics Department in Miskolc University and the ATOMKI Institute in Debrecen. We have been the first to measure resonant Auger spectra after electron-impact excitation of the target (Ar 2p in our case).
- High-resolution x-ray spectrometry:
 - a) In 2007 we twice had beamtime at the ELETTRA synchrotron. In collaboration with the group of prof. Dousse from the Physics Department of Fribourg University we measured inelastically scattered light - the L_β line - when the incoming photons were passing over the L₃ threshold in xenon. In the second experiment we measured the inelastic scattering yield with high resolution in the region of the L threshold of Mo and Pd.
 - b) We were twice at the ESRF synchrotron at the invitation of dr. P. Glatzel, the responsible person for the ID26 beamline. We have measured the x-ray resonant Raman scattering on SF₆ and H₂S molecules and have characterized for the first time the resonant Raman scattering process on doubly excited states (in our case the states were built on the KL holes in argon). We were also happy to detect for the first time the resonant Raman effect in the radiative resonant Auger decay of the K hole in argon.
 - c) In collaboration with the group of ID26 and several foreign researchers (Univ. of Camerino, Univ. of Sheffield, and Univ. of Southampton) we have measured high-resolution x-ray Raman maps of Mo and S in volcanic glass samples and in various kinds of minerals.
- At the DESY synchrotron in Hamburg we have been the first to measure a complete atomic absorption spectrum of caesium vapour (at 700° C) in the region of the L edges. For this our new high-temperature absorption cell with Be windows was used. Also successful was our attempt at ESRF to measure the K-edge absorption spectrum of iodine monoatomic vapour, which was generated by thermal decomposition of I₂ at 900°C. Nobody has managed to do this before.
- We have determined the structure of many new (nano)materials with the EXAFS and XANES techniques at ELETTRA, HASYLAB, DESY and ESRF and have also used this tool for research in the area of environmental protection and cultural heritage:
 - a) Structural studies of micro- and mesoporous catalytic molecular sieves were made in collaboration with the Laboratory of Anorganic Chemistry and Technology from the Institute of Chemistry in Ljubljana.
 - b) Studies of the precursor effect in liquid and amorphous phases on the crystallisation process of thin layers of ferroelectric ceramics of Pb and La zirconate and on TiO₂/ZrO₂ self-cleaning layers after the sol-gel process.
 - c) Very successful was a pilot study of thin-layered nanostructured batteries Li₂Mn_{0.5}Fe_{0.5}SiO₄, where our Fe and Mn XANES and EXAFS studies have shown the presence of reversible valence and structural changes when batteries were following an empty-fill cycle.
 - d) We have studied the interaction of 6-valent Cr with acids in the soil, and have also investigated the nature of Cd bonding in some plants from the Mežiška dolina region.
 - e) We have applied our technique to investigate the effect of iron-gal inks on the process of ageing of old manuscripts.
- In the frame of our collaboration at the ALOISA/HASPES beamline at the ELETTRA synchrotron we have investigated schemes of self-organisation and inter-molecule recognition in the process of forming the ultra-thin biomolecular layers on the ordered surfaces of noble, or quasi-noble metals:
 - a) In the case of the spontaneous ordering of extended amino-acid chains on Ag(111) we showed that the ordering of L-metionin molecules (L-m) into more than 100-nm-long, double (or quadruple) chains proceeds along the zwitterion intermolecular coupling or dimerization of molecules over amino (NH₃⁺) and carboxyl (COO⁻) functional groups. An observed effective repulsing interaction between the parallel amino-acid chains has a long range and reflects the confinement of a two-dimensional electronic gas of the Ag(111) surface in between the macromolecular chains.
 - b) We have shown that long L-m chains are ordered into a periodic configuration (2–20 nm), forming a biomolecular nanomesh, which is ordered on the mesoscopic scale. The inter-chain distance can be changed with the quantity of introduced L-m molecules. A detected amino-carboxyl scheme of molecular coupling represents a universal construction pattern in the nano-architecture of the biomolecules at the surfaces.
- With Mossbauer spectroscopy we have obtained high-resolution data concerning the properties of iron in different samples:
 - a) we have investigated nano-porous LiFe phosphates, silicates and titanates, which are used as a material for building Li-battery cathodes.
 - b) Sediment studies of the upper part of the Kolpa river flow have shown considerable pollution with barium. In nanocrystalline barium hexaferrite we have determined the occupation of 5 different crystallographic positions of Fe and their effect on the properties of the material.
 - c) We have determined the Fe²⁺/Fe³⁺ ratio in iron-gal ink.
 - d) A magnetic ordering and relaxation was studied in multi-ferroic materials.

- In 2007 we have continued research on the interaction of vibrationally excited hydrogen molecules (H_2 and D_2) with different surfaces:
 - a) we have designed and produced the source of vibrationally excited molecules and determined their properties using our in-house-built spectrometer.
 - b) We began to study the effect of the initial hydrogen-gas excitation on the plasma properties when the gas is injected into the plasma. The pilot measurements were made with optical emission spectroscopy and were performed in collaboration with the group for Plasma Physics at the Research Centre in Jülich (Germany) and the Department for Reactor Physics (F8) JSI.
 - c) The same source of vibrationally excited hydrogen was employed to study the chemical erosion of the carbon layers in collaboration with the Max-Planck Institut for plasma physics in Garching, Germany.
 - d) We have studied the production of $H_2(v)$ and $D_2(v)$ in the process of atomic recombination on the surface of tungsten.
- Work with ion beams was mainly done using the external ion beam (arhaeometry) and ion microprobe:
 - a) the first pilot measurements were made to measure the deuterium concentrations in solid samples with a micron lateral resolution. This was done in the framework of the Euroatom project .
 - b) Characterization of aerosol micro-particles with a 3D resolution where the x-ray polycapillary was mounted on the snout of the x-ray spectrometer. This is a continuation of the collaboration that started last year and involves a group of researchers from University Demokritos in Athens (Greece) and a group from the Technical University in Berlin (Germany).
 - c) We have started to work on the production of micro-petri slides with the micromachining technique in collaboration with a group of researchers from Saclay (France).
 - d) We have continued to generate elemental micro-maps of different biological samples in collaboration with the Faculty of Biology in Ljubljana.
 - e) Together with the group of researchers from Tohoku University in Sendai (Japan) we are working on a procedure for the characterization of submicron aerosol particles and single-larger aerosol particles with the ion microprobe.
 - f) We have constructed a new beamline for ERDA and RBS ion-beam analysis, where a higher-quality vacuum is achieved and more precise positioning of the sample is achieved with respect to the old chamber. The line was officially put into use by the JSI director on the occasion of the 10th anniversary of the Tandetron accelerator in our lab. This event was also celebrated by a colloquium of prof. dr. Povh at the JSI and a short review presentation of the past and future aims of the group at the Microanalytical Center.

Some outstanding publications in 2007

1. A. Acha et al. (Hall A Collaboration), Precision measurements of the nucleon strange form factors at $Q^2 = 0.1$ GeV^2 , Phys. Rev. Lett. 98 (2007) 032301.
2. A. Danagoulian et al. (Hall A Collaboration), Compton scattering cross section on the proton at high momentum transfer, Phys. Rev. Lett. 98 (2007) 152001.
3. R. Shneor et al. (Hall A Collaboration), Investigation of proton-proton short-range correlations via the $12C(e,e'pp)$ reaction, Phys. Rev. Lett. 99 (2007) 072501
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1. Zdravko Rupnik, Drago Brodnik, Matej Lipoglavšek
Instrument and procedure for flow detection in metallic capillary: patent SI22174 A
Ljubljana, The Slovenian Intellectual Property Office, 2007

Awards and appointments

1. Miha Mihovilovič: Faculty Prešeren Prize for the Diploma Work "Tracking of unstable particles in magnetic spectrometers", supervisor Simon Širca, 29. 11. 2007
2. Žiga Šmit: Valvasor award of honor in 2007, Slovenian Museum Society, 17. 05. 2007

Organization of conferences, congresses and meetings

1. 3rd Forschungszentrum Jülich - Jožef Stefan Institute meeting on PWI, Ljubljana, Slovenia, 19. 02.-21. 02. 2007, organizer Iztok Čadež

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Invited Papers

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Dynamics of P11 and P33 resonances in quark models with chiral mesons: [presented at Mini-workshop Hadron Structure and Lattice QCD, Bled, July 6-16, 2007]
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In: Blejsk. delavn. fiz., Let. 8, No. 1, pp. 70-75, 2007.
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Regular Papers

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B. SC. THESES

1. Martina Čehovin: Quality assurance of stereotactic radiotherapy with Winston-Lutz test (A. Likar)
2. Luka Debenjak: Measurements with scintillating fibers for prototype detector of spectrometer Kaos (S. Širca)
3. Barbara Gašperlin: Study of the inhibitors of corrosion in concrete (co-mentor Ž. Šmit)
4. Martina Glušič: Tolerance strategy on salinity of selected halophytes from Sečovlje saltpan (co-mentor P. Kump)
5. Nataša Grlj: Use of polycapillaries in micro PIXE, characterization and depth profiling of samples (M. Žitnik)
6. Jernej Györkös: Distribution of I-125 in carbon filter and determination of filter efficiency (A. Likar)
7. Miha Mihovilovič: Tracking of unstable particles in magnetic spectrometers (S. Širca)
8. Iztok Miklavžina: Measurement of photon doses in the environment (S. Širca)
9. Matija Perne: An advection model of limestone dissolution and the formation of rillenkarren (A. Kodre)
10. Toni Petrovič: Calibration of the Afrodite detector system (M. Lipoglavšek)
11. Monika Pogorelec: Accumulation of Pb, Zn, and Cd at iva Slix caprea from contaminated area in Žerjav (co-mentor P. Kump)

INTERNATIONAL PROJECTS

1. Application of Ion Beam Analytical Methods to the Studies of Plasma Wall Interaction in Tokamaks - P5-FU, EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC, RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Primož Pelicon
2. Interaction of Vibrationally Excited Hydrogen with Fusion Relevant Materials - P2-FU
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC, RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Iztok Čadež
3. Holder for Annular Source, including Pure Sn Collimator, to fit a Si(Li) Detector
RAF0023-9283OL
IAEA, Vienna, Austria
Dr. Peter Kump
4. Holder for Annular Source, including Pure Sn Collimator
ARG13864-88523F
IAEA, Vienna, Austria
Dr. Peter Kump
5. Improvement of the XRF Quantification and Enhancement of the Combined Applications by EDXRF and Micro PIXE
13858/RBF, RO, R1
IAEA, Vienna, Austria
Dr. Peter Kump
6. Technical Cooperation Project RER/1/006: Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region
IAEA, Vienna, Austria
Prof. Žiga Šmit
7. Development of Post-emergency Impact Assessment Capability
IAEA, SLO/9/012
Dr. Alain Cardoso, IAEA, Vienna, Austria
Dr. Matjaž Aleš Korun
8. Material Analysis of the Objects of Cultural Heritage from the Slovenian and Albanian Area
BI-AL/06-08-001
Prof. Aferdita Vevecka-Priftaj, Polytechnic University Tirana, Tirana, Albania
Prof. Žiga Šmit
9. Novel Detection Techniques in pulsed Coincidence Experiments
BI-FR07-PROTEUS-010
Dr. Francis Penent, Lab de chimie physique matiere et rayonnement CNRS, Unite UMR, Paris, France
Asst. Prof. Matjaž Žitnik
10. Convention de mise a disposition
Contract between CNRS and JSI dated 27.5.2004
Letter N/REF: NS/MD/CONV/04FRE2681JS/2004 dated 8.9.2004
Dr. Paul Indelicato, Laboratoire Kastler-Brossel (LKB - UMR 8552), Ecole normale superieure, Paris, France
Dr. Iztok Čadež
11. Atomic X-ray Absorption of Iodine by Thermal Decomposition of I₂ Vapor HD-156
Dr. Sacura Pascarelli, dr. Simone de Panfilis, ESRF - European Synchrotron Radiation Facility, Grenoble, France
Prof. Alojz Kodre
12. XAFS Study of La and Zr Local Environment in Amorphous Precursors of La₂Zr₂O₇ Ceramics
ELETTRA Project Number 2006114
Luca Olivi, Sincrotrone ELETTRA, Trieste, Italy
Prof. Iztok Arčon
13. XAS Studies of Ti, V, Mn and Fe Local Environment in Hierarchical Porous Catalysts
ELETTRA Project Number 2007356
Luca Olivi, Sincrotrone ELETTRA, Trieste, Italy
Prof. Iztok Arčon
14. XAS Studies of Ti, Mn and Fe Cations Local Environment in Catalysts for Oxidation Reactions
ELETTRA Project Number 2005247
Luca Olivi, Sincrotrone ELETTRA, Trieste, Italy
Prof. Iztok Arčon
15. Molecular Orientation of Thin PTCDA Films by Means of Angle Resolved Resonant Photoemission
Elettra Project Number 2006818
Dr. Luca Floreano, Lab. TASC/INFN-CNR, Trieste, Italy
Asst. Prof. Dean Cvetko
16. Application of Ion Beam Technology to Environmental Research
BI-JPN/07-09-02
Dr. Ishii Keizo, Department of Quantum Science and Energy Engineering, Tohoku University, Sendai, Japan
Asst. Prof. Primož Pelicon
17. Calculation of Efficiencies and True Coincidence Summing Corrections for Environmental Gamma-ray Spectrometry
BI-HU/07-08-005
Dr. Sándor Sudár, Univerza v Debrecenu, Institut za eksperimentalno fiziko, Debrecen, Hungary
Prof. Andrej Likar
18. Investigation of Electron Emission after Electronic and Ionic Collision of Atoms by Coincidence Zechinque
BI-HU/06-07/015
Prof. Karoly Tokesi, Institute of Nuclear Research of The Hungarian Academy of Sciences, Debrecen, Hungary
Dr. Matjaž Kavčič
19. Application of Scanning Nuclear Microprobe Techniques in the Field of Nanotechnology and Microbiology
BI-HU/06-07/016
Prof. Imre Uzonyi, Institute of Nuclear Research of The Hungarian Academy of Sciences, Debrecen, Hungary
Asst. Prof. Primož Pelicon
20. Atomic Absorption in the L-edge Region
II-04-065 EC
Prof. Jochen R. Schneider, dr. Konstantin Klementiev, Synchrotron Laboratory (Synchrotron Radiation Facility) HASYLAB (Hamburger Synchrotronstrahlungslabor), DESY (Deutsches Elektronen Synchrotron), Hamburg, Germany
Prof. Alojz Kodre
21. Development of Java GUI's for Use in DESY Accelerator Control Attachment #7
Dr. M. Clausen, DESY (Deutsches Elektronen Synchrotron), Hamburg, Germany
Dr. Mark Pleško
22. Hi-Light Agreement
Hi-Light, Opto Electronics BV, Tolbert, The Netherland
Dr. Matjaž Vencelj
23. Nucleon in the Spektral Quark Model
BI-PL/05-07-008
Prof. Broniowski Wojciech, Instytut Fizyki Jadrowej, Krakow, Poland
Asst. Prof. Simon Širca, Prof. Bojan Golli
24. Nucleon Resonances in Chiral Models
BI-PT/06-07-005
Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
Asst. Prof. Simon Širca, Prof. Bojan Golli

25. Quantum Mechanics of Nuclear Radiative Capture Models based on Optical Potential
BI-SK/05-07-003
Asst. Prof. Rndr. Drsc. Emil Betak, Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia
Prof. Andrej Likar
26. Studies of Parity Violation in H/He and Electromagnetic Structure of the Deuteron
BI-US/06-07-048
Gilad Shalev, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA
Asst. Prof. Simon Širca
15. Assessment of the environmental impact of military training ground Krivolak with the aim of its ecological remediation
Ass. Prof. Matej Lipoglavšek
16. Study of thin organic films and nanostructured materials by synchrotron radiation
Ass. Prof. Dean Cvetko
17. Development of the diagnostics for certain parameters of the edge plasma in fusion devices
Prof. Milan Čerček
18. Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
Ass. Prof. Darko Makovec

R & D GRANTS AND CONTRACTS

1. In Beam Spectroscopy
Ass. Prof. Matej Lipoglavšek
2. Processes with vibrationally excited molecules
Dr. Iztok Čadež
3. Electron screening in metals and alloys
Ass. Prof. Matej Lipoglavšek
4. Novel, environmental friendly, high energy density materials for use in Li-ion batteries
Dr. Robert Dominko
5. Non-destructive analytical methods as a basis of historical and art-historical research
Prof. Žiga Šmit
6. Development and introduction of new analysis methods in gamma-ray
Dr. Matjaž Aleš Korun
7. Inventory of Secovlje saltpan flora and optimisation of growth of autochthonous *Salicornia* species
Dr. Marijan Nečemer
8. Evaluation of peak areas and their uncertainties in gamma-ray spectrometry
Dr. Matjaž Aleš Korun
9. Dating of Waters by H-3 and Pb-210: groundwater dynamics and vulnerability of deep aquifers
Dr. Jasmina Kožar Logar
10. Application of x-ray analytical techniques
Dr. Peter Kump
11. Age, origin and dynamics of deep aquifer's groundwaters of Ljubljansko barje
Dr. Jasmina Kožar Logar
12. Tracing of tritium in the environment around the Krško NPP
Dr. Matjaž Aleš Korun
13. Determination of geographical and botanical origin of honey
Dr. Marijan Nečemer
14. Fusion relevant research of plasma interactions with surfaces
Prof. Milan Čerček

RESEARCH PROGRAMS

1. Structure of hadronic systems
Ass. Prof. Simon Širca
2. Studies of atoms, molecules and structures with photons and particles
Ass. Prof. Matjaž Žitnik
3. Mobile archaeological heritage: archaeological and archaeometric investigations
Prof. Žiga Šmit

NEW CONTRACTS

1. Monitoring of radioactivity of drinking water 2007
Ministry of health
Dr. Matjaž Aleš Korun
2. Off-site radiological monitoring of the Krško NPP
Krško NPP
Dr. Matjaž Aleš Korun
3. Cofinancing of project Evaluation of peak areas and their uncertainties in gamma-ray spectrometry
Ames d.o.o.
Dr. Matjaž Aleš Korun
4. Cofinancing of Ecological laboratory with mobile unit (ELME) in 2007
Ministry of defence
Asst. Prof. Matej Lipoglavšek
5. Realisation of measurements according to the program of initial measurements on the location Vrblina
Agency of radwaste management
Denis Glavič Cindro, M. Sc
6. Emergency response preparedness of ELME 2007-2012
Krško NPP
Asst. Prof. Matej Lipoglavšek

VISITORS FROM ABROAD

1. Dr. Emil Bták, Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia, 15. 01.-27. 01. 2007
2. Dr. Kazimierz Rozanski, AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland, 28. 01.-03. 02. 2007
3. Dr. Sebastjan Brezinsek, Dr. Arkadi Kreter, Institut für Plasmaphysik, Forschungszentrum, Jülich, Germany, Dr. Marek Rubel, Alfvénov Laboratorij, Royal Institute of Technology, Stockholm, Sweden, 19. 02.-21. 02. 2007
4. Mr. Tadeuzs Kuc, AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland, 11. 04.-21. 04. 2007
5. Dr. Frederik Stamatii, National Museum of Archaeology, Tirana, Albania, 14. 05.-20. 05. 2007
6. Prof. Dr. Aferdita Vevecka-Priftaj, Politechnical University of Tirana, Tirana, Albania, 14. 05.-20. 05. 2007
7. Prof. Dr. Bela Paripás, Prof. Dr. Bela Palasthy, University of Miskolc, Hungary, 27. 06.-03. 07. 2007
8. Dr. Roman Shuetz, TU-Berlin, Institut für Atomare Physik und Fachdidaktik, Berlin, Germany, 17. 07.-29. 07. 2007
9. Mr. Demostenis Sokaras, Institute of Nuclear Physics, NCSR Demokritos, Athens, Greece, 18. 07.-28. 07. 2007
10. Dr. Andreas Karydas, Institute of Nuclear Physics, NCSR Demokritos, Athens, Greece, 23. 07.-26. 07. 2007
11. Dr. Birgit Kangiesser, TU-Berlin, Institut für Atomare Physik und Fachdidaktik, Berlin, Germany, 23. 07.-29. 07. 2007
12. Prof. Dr. Keizo Ishii, Tohoku University, Sendai, Japan, 10. 10.-16. 10. 2007
13. Dr. Marie Carriere, Dr. Hicham Khodja, Laboratoire Pierre Sue, CEA-Saclay, France, 28. 10.-31. 10. 2007
14. Prof. Dr. Shigeo Matsuyama, Department of Quantum Science and Energy Engineering, Tohoku University, Sendai, Japan, 08. 11.-13. 11. 2007
15. Dr. Sandor Sudar, Dr. Zoltan Dezso, ATOMKI, Debrecen, Hungary, 09. 11.-16. 11. 2007
16. Dr. Emil Bták, Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia, 11. 11.-21. 11. 2007
17. Ms. Julia Jungmann, Kernfysisch Versnellend Instituut, University of Groningen, Groningen, The Netherlands, 12. 11.-11. 12. 2007
18. Dr. Hicham Khodja, Laboratoire Pierre Sue, CEA-Saclay, France, 02. 12.-05. 12. 2007
19. Prof. Dr. Bogdan Povh, University of Heidelberg, Germany, 30. 11. 2007
20. Dr. Francis Penent, Laboratoire de chimie physique – matiere et rayonnement, UPMC, Paris, France, 02. 12.-08. 12. 2007
21. Dr. Károly Tökési, ATOMKI, Debrecen, Hungary, 01. 12.-07. 12. 2007
22. Prof. Dr. Hirimichi Yamazaki, Department of Quantum Science and Energy Engineering, Tohoku University, Sendai, Japan, 17. 12.-21. 12. 2007

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6. Prof. Alojzij Franc Kodre*
7. *Dr. Matjaž Aleš Korun – left 13. 12. 2007*
8. Dr. Peter Kump
9. Prof. Andrej Likar*
10. **Asst. Prof. Matej Lipoglavšek**, Head**

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12. Dr. Marijan Nečemer
13. Asst. Prof. Primož Pelicon**
14. Dr. Mark Pleško
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16. Asst. Prof. Simon Širca*
17. Prof. Žiga Šmit*
18. Dr. Matjaž Štuhec
19. Dr. Tim Vidmar
20. Asst. Prof. Matjaž Žitnik**
- Postdoctoral associates**
21. *Dr. Gregor Bavdek, ** - left 01. 01. 2007*
22. Dr. Klemen Bučar**
23. Dr. Jasmina Kožar Logar

- 24. Dr. Andrej Mihelič**
- 25. *Dr. Jurij Simčič - left 15. 09. 2007*
- 26. Dr. Matjaž Vencelj
- 27. Dr. Benjamin Zorko

Postgraduates

- 28. Luka Debenjak, B. Sc.
- 29. David Jezeršek, B. Sc.
- 30. Sabina Markelj, B. Sc.
- 31. Miha Mihovilovič, B. Sc.

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- 32. Boštjan Črnič, B. Sc.
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- 36. Zdravko Rupnik, M. Sc.
- 37. Primož Vavpetič, B. Sc.
- 38. Branko Vodenik, M. Sc.

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- 39. Drago Brodnik
- 40. Mojca Gantar
- 41. Sandi Gobec
- 42. Zvonimir Grabnar
- 43. Mirko Ribič
- 44. Sonja Wostner

* Full-time faculty member

** Part-time faculty member

DEPARTMENT OF THIN FILMS AND SURFACES

F-3

The main field of research in the Department of Thin Films and Surfaces is the development, deposition and characterization of hard protective PVD coatings. However, research is also done in other fields of thin films and surface physics. Basic research is concentrated on the study of the physical and chemical properties of various multicomponent, multilayer and nanostructured coatings, as well as the study of processes during heat treatment. Among the applied research activities, different coatings are being developed for the protection of tools for various production processes in industry.



Head:
Dr. Peter Panjan

The central part of research in 2007 remained in the area of hard protective coatings, with an emphasis on multilayer coatings. We continued to study the multilayer systems TiN/TiAlN and CrN/TiAlN with modulations on the nanometre scale. We analysed in detail the crystal structure at the phase boundaries of the substrate/coating and at the internal phase boundaries, and confirmed a high degree of coherence. We also continued to model coating growth during the deposition of multilayer coatings, for which the German company CemeCon showed a lot of interest. In order to test these findings in other configurations, the young researcher Matjaž Panjan left for a three-month secondment to the R&D department of this company, where he was engaged in the deposition of other multilayer coatings based on transition-metal nitrides.

In 2007 we commenced research in a new field, the protection of aluminium alloys against wear and corrosion, which represents a major problem for industry. New procedures are being searched for as alternatives for ecologically problematic chromate coatings. One of the possible solutions is PVD coatings. Our research has shown that when using new PVD coatings the corrosion resistance of aluminium alloys can increase by a factor of 100, and in this way represent a serious alternative to electrochemical chrome.

Micro-defects in PVD coatings are a generally known phenomenon, but it is one that is relatively poorly understood. In the past two years we have worked more closely on determining the origin of these defects, the formation mechanisms and the possibilities to decrease the number of defects. In collaboration with the University of Maribor we showed that the focused ion-beam technique is a very useful way of studying the structure of these defects. Part of this work was done within the project "Nanostructured surfaces and interfaces", which is a topic of the Centre of Excellence "Nanotechnologies and Nanosciences".

Closely related to defects, the surface topography is of key importance for the adhesion of hard coatings. We systematically analysed the topography of bare substrates made of various steels, the substrate topography after ion etching, and the surface topography after the deposition of hard coating. We found that the topography is strongly influenced by the type and size of the carbide inclusions in steel. The most important quantity is the ion-etching rate, which determines whether there will be hills or valleys on the sites of the inclusions. These data help us to optimise the ion-etching parameters.

Besides standard tools for topographical studies, such as scanning electron microscopy and atomic force microscopy, we have a contact 3D-profilometer in operation, starting this year. Our profilometer was previously only able to produce line scans; however, it was recently upgraded with a 3D manipulation unit and the respective software. In this regard we can scan surfaces to a maximum extent of 5×10 cm and resolutions of $0.25 \mu\text{m}$ in the x direction, $1 \mu\text{m}$ in the y direction and 3 nm in the z direction.

In the Hard Coatings Centre, which operates within the department, we are coating tools with hard protective coatings for Slovenian industry. In addition to the coating of end-products, we collaborate with several partners in the development of coating applications for a given production process or help to solve various technological problems. Among the new coatings developed at the centre, we should mention a bilayer TiCN coating with a lubricant amorphous carbon topcoat.

The department intensively collaborates with other institutions, both research and industrial, in Slovenia and abroad. Besides the above-mentioned collaboration with the German company CemeCon, the key partner in 2007 was Joanneum Research, from Austria. Our researcher Dr. Miha Čekada spent three months as a guest scientist in the department at the Laser Center Leoben. He was engaged in the deposition of diamond-like films using a relatively poorly known technique called "anode layer source". He



Figure 1: Surface topography of a crater, prepared by glow-discharge optical spectrometry (picture width is 5 mm, crater depth $5 \mu\text{m}$)

For the American company PPG we successfully developed a coating for the corrosion protection of aluminium alloys.

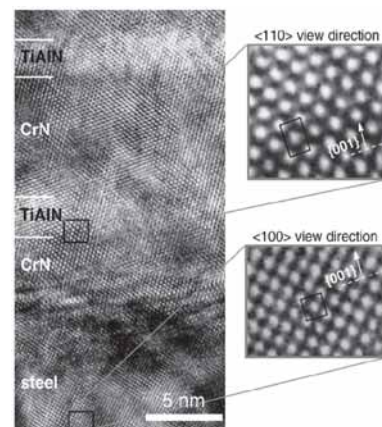


Figure 2: Cross-section of the multilayered coating TiAlN/CrN obtained by transmission electron microscopy at atomic resolution

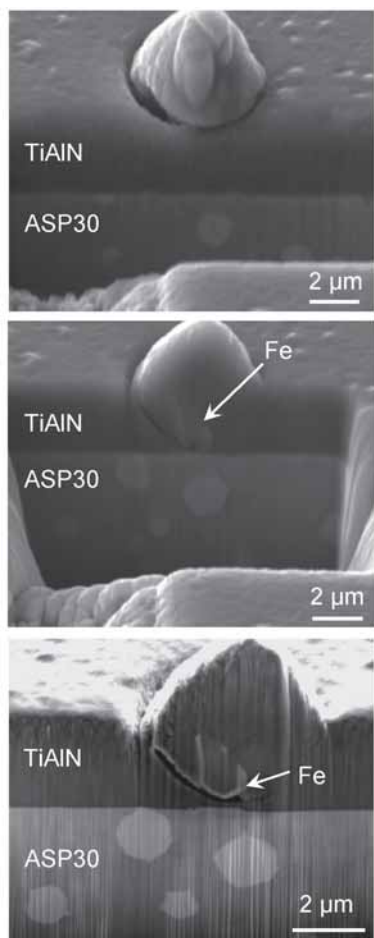


Figure 3: Three phases of the cross-section of a defect in a TiAlN coating. We also determined the chemical composition of individual parts of the defect.

was able to prepare a series of coatings with advantageous mechanical properties, while the department conducted a thorough characterization of these coatings. Part of the collaboration was dedicated to the deposition of CrN coatings by pulsed sputtering.

We are part of an EU 6FP Network of Excellence called “Complex metallic alloys”, where we analysed in detail the diffusion processes during the heat treatment of the multilayer structures Al/Cr, Al/Fe and Cr/Fe. Using different numerical methods we modelled the composition depth profile obtained by Auger electron spectroscopy, and in this way determined the diffusion parameters more precisely. We are also part of a Eureka project, where we study the wear resistance of steels prepared by sintering. Partners from four countries are involved, while from Slovenia the participants are the Institute for Metals and Technologies, Unior and Iskra Mehanizmi.

There are also bilateral collaborations with partners abroad. For the American company PPG we developed procedures for the corrosion protection of aluminium by various coatings based on aluminium and tungsten, and chromium nitride. In cooperation with the Mechanical Engineering Faculty from Zagreb University we measured composition depth profiles using glow-discharge optical emission spectrometry, which is also a complementary method for studying the microstructure and defects in the coating. Together with the Institute for Nuclear Sciences “Vinča” from Belgrade we are working in the area of the laser treatment of solid surfaces. Our task is to prepare the desired coatings and to analyse the surface damage at the spot of the laser interaction. We specialized in the topography and 3D analysis of craters.

Collaboration at the national level includes the characterization of iron oxides (with the Faculty of Natural Sciences and Technology, University of Ljubljana), where we compared different techniques for determining a coating’s chemical composition. With the company PHOS from Sečovlje we are developing coatings for the pharmaceutical industry, while for Gorenje Orodjarna we conducted a study on the protection of aluminium tools. We performed a series of other smaller projects, dedicated to narrowly defined problems from industry. In collaboration with the Department of Surface Technology and Optoelectronics we prepared coatings of CrC, C, Cr and Cr/Si for the measurement of sputtering rates, and coatings of WC for studying the chemical states of carbon. For the technological journal IRT3000 we prepared a thematic issue on the application of hard coatings in various industrial areas.

Some outstanding publications in the past three years

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2. M. Čekada, P. Panjan, J. Dolinšek, A. Zalar, Z. Medunič, M. Jakšič, N. Radič, Diffusion during annealing of Al/Cu/Fe thin films, *Thin Solid Films* 515 (2007), 7135–7139
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4. M. Maček, M. Mišina, M. Čekada, P. Panjan, Energy-resolved mass spectroscopy studies during the deposition of TiC films by ion plating under different magnetic fields, *Vacuum* 80 (2005) 184–188
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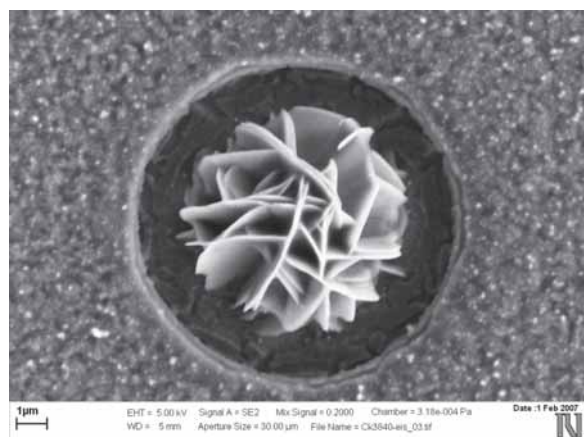


Figure 4: SEM micrograph of a spot of pitting corrosion in the CrN coating

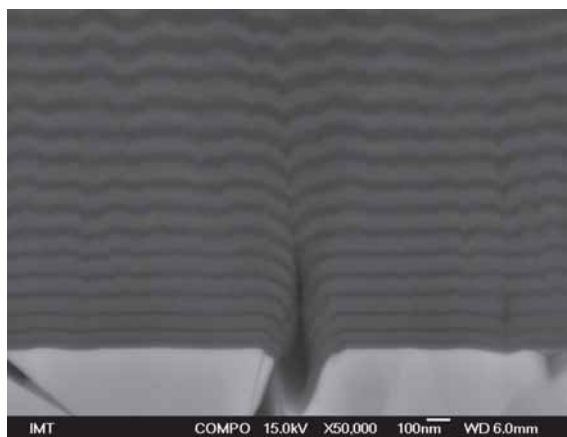


Figure 5: SEM micrograph of a cross-section of the multilayer coating CrN/TiAlN on a hard metal substrate. In the centre of the coating, closing of the gap is clearly visible, which appeared at the spot of a defect in the substrate.

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Invited Paper

- Aleš Petek, Bojan Podgornik, Karl Kuzman, Miha Čekada, W. Waldhauser, Jože Vižintin
The analysis of tribological process during incremental sheet metal forming
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- Marta Klanjšek Gunde, Matjaž Kunaver, Miha Čekada
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B. SC. THESES

- Srečko Paskvale: Ion etching of tool materials before deposition of hard coatings (Janez Dolinšek, Peter Panjan)
- Darjan Cimprič: Diffusion processes during annealing of multilayer structures Al-Cr-Fe (Janez Dolinšek, Miha Čekada)
- Branko Ušaj: High-speed milling of matrices for production of teeth (Peter Panjan)

INTERNATIONAL PROJECTS

- Complex Metallic Alloys
CMA, 6. FP, NMP3-CT-2005-500140
EC; Centre National de la Recherche Scientifique, Paris, France
Dr. Peter Panjan, Prof. Janez Dolinšek, Prof. Spomenka Kobe
- Progressive Surfacing of Metals
EUREKA projekt E13437
Dr. Peter Jurčič, Ecosond, s.r.o., Prague, Czech Republic
Dr. Peter Panjan
- Characterization of Composition and Mechanical Properties of PVD Ceramic Coatings
BI-HR/07-09-001
Dr. Lidija Čurković, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia
Dr. Peter Panjan
- Characterization of the Selected Coatings
Dr. Rainer Cremer, CemeCon AG, Coatings, Technology & Processes, Würselen, Germany
Dr. Peter Panjan
- Thin Films Modification on Micro-and Nano-Level
BI-CS/06-07-003

Dr. Biljana Gaković, Institut za nuklearne nauke "Vinča", Belgrade, Serbia

Dr. Peter Panjan

- PVD Coatings for Protection of Aluminium-based Substrates for Aircraft Applications
Dr. Michael Pawlik, PPG Industries, Inc., One PPG Place, Pittsburg, Pennsylvania;
Rosanna Drive, Allison Park, PA, USA
Dr. Peter Panjan, Dr. Ingrid Milošev

R & D GRANTS AND CONTRACTS

- PVD hard coatings as an alternative for corrosion protection of Fe- and Al-alloys
Dr. Darinka Kek Merl
- Smart functional coatings for improvement of structures and components used in defensive purpose
Dr. Peter Panjan

RESEARCH PROGRAM

- Thin film structures and plasma surface engineering
Prof. Anton Zalar

VISITORS FROM ABROAD

1. dr. Biljana Gaković, dr. Suzana Petrović, Dubravka Marović, Institute for nuclear sciences "Vinča", Belgrade, Serbia, 14.-18. 5. 2007
 2. mag. Tamara Novakov, University of Novi Sad, Faculty for technical sciences, Novi Sad, Serbia, 15. 5. - 15. 7. 2007
 3. Ljiljana Maksimović, PPG Industries, Inc., Pittsburgh, USA, 14. 6. 2007
 4. dr. Mirka Alunovic, CemeCon AG, Würselen, Germany, 18. 6. 2007
 5. Arjen van Zeijst, Hauzer Techno, Venlo, The Netherlands, 10.-11. 7. 2007
 6. dr. Wolfgang Waldhauser, mag. Markus Kahn, Roswitha Berghauser, Joanneum Research, Laser Center Leoben, Leoben, Austria, 11. 10. 2007
 7. Gregory Favaro, Fabio Brazzati, CSM Instruments, Neuchâtel, Switzerland, 16. 10. 2007
 8. dr. Rainer Cremer, dr. Christoph Schieffers, CemeCon AG, Würselen, Germany, 16.-17. 10. 2007
 9. dr. Biljana Gaković, dr. Suzana Petrović, dr. Bojan Radak, Institute for nuclear sciences "Vinča", Belgrade, Serbia, 5.-9. 11. 2007
 10. dr. Lidija Čurković, Faculty for mechanical engineering and shipbuilding, Zagreb, Croatia, 12.-14. 11. 2007
-

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 2. Dr. Darinka Kek Merl
 3. **Dr. Peter Panjan, Head**
- ### Postgraduates
4. Matjaž Panjan, B. Sc.
 5. Srečko Paskvale, B. Sc.

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6. Dr. Marijan Maček*

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7. Jožko Fišer
8. Damjan Matelič
9. Andrej Mohar
10. Tomaž Sirnik

* Full-time faculty member

DEPARTMENT OF SURFACE ENGINEERING AND OPTOELECTRONICS

F-4

The main activities of the Department of Surface Engineering and Optoelectronics are oriented towards surface engineering, surface, interface and thin-film characterization, plasma applications, the synthesis of nano- and biomedical materials, vacuum optoelectronics, ultra-high-vacuum techniques and technologies. The department collaborates with other groups at the JSI as well as with other Slovenian and foreign institutes, universities and industrial companies. The group is also active in the field of the education of students at two Slovenian universities and at the Jožef Stefan International Postgraduate School.



Head:
Prof. Anton Zalar

In recent decades a large number of new techniques have been developed that are indispensable for the characterization of the surfaces and interfaces of materials. In the department Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS) and atomic force microscopy (AFM) have been used successfully, all for basic research and for the characterization of technological samples. Our research group specialises in the depth profiling of thin films and multilayers.

To study the ion sputtering of a layered structure with different ion-sputtering yields, a trilayer structure of C-graphite/ Cr_3C_2 /Cr was sputter deposited onto smooth silicon substrates. The ion-sputtering rates of the amorphous carbon, the amorphous Cr_3C_2 and the polycrystalline Cr were determined by means of Auger electron spectroscopy depth profiling as a function of the angle of incidence of two symmetrically inclined 1 keV Ar^+ ion beams in the range 22–82°. The sputtering rates were calculated from the known thicknesses of the layers and the sputtering times necessary to remove the individual layers. The sputtering rates of all three components were strongly dependent on the angle. The experimental sputtering yields were in agreement with the theoretical results obtained by calculation of the transport of ions in solids, but the sputtering yields of C-graphite measured at larger ion-incidence angles were smaller than the simulated yields.

In cooperation with the Institute for Technical Physics and Materials Science in Budapest we have determined the relative sputtering yields of $Y_{\text{Cr}}/Y_{\text{Si}}$ for 1-keV Ar^+ ions at ion-incidence angles in the range 22–87°. The experimentally measured sputtering yields quantitatively follow the trend from the SRIM simulation. However, some of the deviation might be explained by the influence of the ion-induced surface topography.

AES sputter depth profiles of multilayers with constituents of very different backscattering factors show characteristic distortions in the shape of the intensity-depth profiles. In cooperation with the Max-Planck Institute for Metals Research in Stuttgart it was shown for a Ni/C multilayer structure on a Si substrate that AES intensity depth profiles calculated with the modified MRI (mixing, roughness, information) model yield an excellent agreement with the experimentally obtained profile after some adjustment of the initial mean effective backscattering decay lengths, and, sometimes, after a slight change of the backscattering factors.

Using AES and XPS methods we characterized thin Fe-oxide layers prepared by the low-temperature oxidation of Fe electromagnetic sheets. The electrical, mechanical and protective properties of Fe-oxide layers depend strongly on their thickness, composition, and the type of Fe-oxide and adhesion of these layers. We found that the oxide layer consists of Fe_2O_3 and Fe_3O_4 . Better adhesion was found on samples with a higher concentration of magnetite Fe_3O_4 , it is related to the diffuse and broad oxide/substrate interface and the cleanliness of the surface before oxidation.

Using the XPS method we investigated tungsten oxide nanowires prepared by transport reaction in collaboration with researchers from the Department of Solid State Physics at the JSI. XPS proved to be very useful for the characterization of the composition, the chemical bonds and the electronic properties of nanostructured materials. We identified 5⁺ and 6⁺ valence states of tungsten atoms in the analysed nanowires (Fig. 1), which in combination with

At the Twinmic x-ray microscope at the Elettra synchrotron light source we introduced, in collaboration with other European partners, a new method for imaging in scanning-transmission mode to measure fast and simultaneous images with absorption and phase contrast.

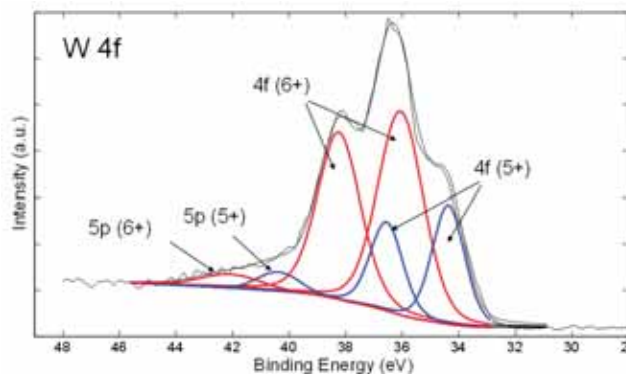


Figure 1: Complex XPS spectrum W 4f obtained in our laboratory on tungsten oxide nanowires prepared in the Department of Solid State Physics at the JSI. The spectrum shows the different valence states of the W atoms, which in combination with the results of diffraction methods allowed us to set up a structural model of the W_5O_{14} nanowires.

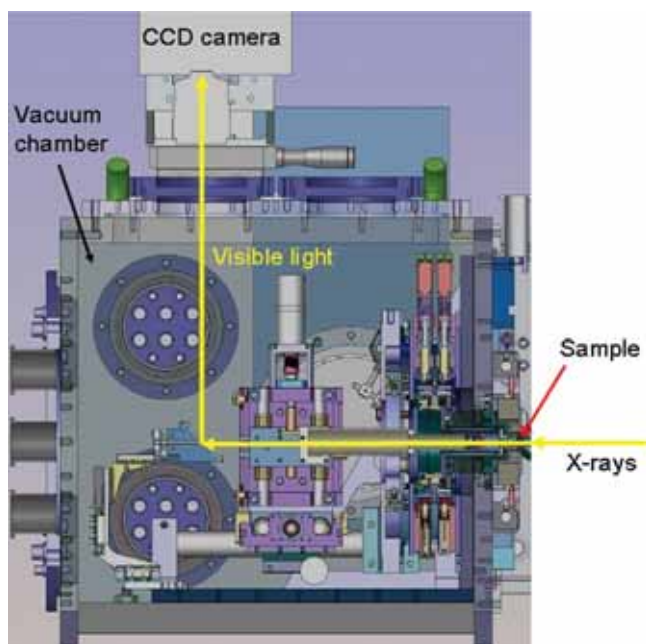


Figure 2: A schematic view of a method for imaging in scanning transmission mode, developed with other European partners at the Twinmic x-ray microscope at the Elettra synchrotron light source.

the results of the diffraction methods allowed us to set up a structural model of the W_5O_{14} nanowires. XPS spectra of the valence band showed a metallic behaviour for these nanowires, which was confirmed by direct current transport measurements.

With the synchrotron light source Elettra in Trieste we further collaborated on an improvement to a new phase-contrast method for the scanning-transmission mode at the Twinmic x-ray microscope, which was built in collaboration with seven other European partners (Fig.2) Using a new method we investigated the distribution of ceramic grains based on SiC during the sintering process and the distribution of wear-debris particles from broken implants in the surrounding tissue.

An important segment of our activities was devoted to surface engineering by weakly ionized highly dissociated thermodynamically non-equilibrium cold gaseous plasma. Most research was performed on the interaction of such plasma with organic materials. In collaboration with our partners in the EU 6FP Vascular Graft Interfaces, a novel method for the functionalization of vascular grafts' surfaces has been developed and the corresponding patent application was submitted. The vascular grafts are made from PET polymer, and part of a graft is shown in Fig.3. The inner surface of the graft is treated by neutral oxygen atoms in the ground state. The atoms interact with the surface, forming extremely polar functional groups at room temperature. The surface is thus ready for the deposition of biocompatible coatings that decrease the risk of thrombosis. We also submitted a patent application on device that enables uniform functionalization of the entire inner surface of the grafts.

Methods for the hydrophilization of different kinds of paper were investigated in collaboration with the Institute for Paper and the National Institute of Chemistry, both from Ljubljana, Slovenia, as well as the Institute of Physics, Zagreb, Croatia. The best method for achieving stable functionalization is a short treatment with a mild oxygen plasma. At the optimal dose of plasma radicals it is possible to remove selectively an ultra-thin hydrophobic film without any modification of the other properties of the paper. The treatment was disclosed in a scientific paper, which was published in a classic journal on applied physics – Journal of Physics D: Applied Physics. The scientific board of this journal found our scientific paper one of the best published in 2007 and accordingly added it to the annual flyer. In the cover letter, the scientific

board stated that our achievement would promote the journal worldwide. A part of the flyer was scanned and is presented in Fig. 4.

Another achievement worth mentioning is the plasma treatment of natural wool. A scientific paper was published in Plasma Chemistry and Plasma Processing, which is among the most prestigious journals specialized in plasma chemistry. In this paper we reported the results of extensive research that has been performed in collaboration with the University Paul Sabatier, Toulouse, France. Natural wool is exposed to neutral oxygen atoms with a

precisely determined flux. The atoms interact with the lipid layer on the surface of the wool, but do not interact with other wool substances. We showed that the lipid layer can be selectively removed from the wool surface, which improves the dyeing process dramatically. A method for monitoring the removal of the lipid layer was disclosed as well. It is based on measuring the O density in the reaction chamber. Since oxygen atoms strongly react with the lipid layer, it represents a sink for the atoms. The O density is therefore very low as long as the lipid layer persists. As soon as it is removed, however, the O atom density increases to a value typical for an empty chamber. Since the catalytic probes that have been developed in our laboratories have a fast response, they allow for real-time monitoring of the wool processing. It is, therefore, possible to determine the right treatment time without breaking the process and wool characterization.

Yet another achievement worth mentioning is the development of a method for real-time monitoring of a sterilization process. In this case, samples are exposed directly to an oxygen plasma. Since catalytic probes are not suitable for the detection of tiny differences in O atom density during the treatment of bacteria, another method was developed. The method is based on optical emission spectroscopy. In collaboration with our partners from the Public Health Institute, Podgorica, Montenegro, and the Institute of Physics, Zagreb, Croatia, we performed a systematic study on the plasma sterilization of biocompatible materials. The emission bands of CO molecules were measured simultaneously during the plasma treatment. As long as bacteria are present on the surface,

We have developed and patented an original method for the functionalization of vascular grafts that allows for an optimal adhesion of biocompatible coatings on the inner surface of the grafts.



Figure 3: A photo of an artificial blood vessel made of PET polymer.

the CO band is clearly visible. As the bacteria are depredated, the emission vanishes. The independent control of the sterilization showed that samples actually became sterile a short time before the CO emission vanished. Optical emission spectroscopy therefore represents a powerful tool for the real-time monitoring of the sterility of biocompatible materials during plasma treatment. The tritium inventory in all inner surfaces contributes an important issue in the safe handling and decommissioning of future fusion reactors. For the ITER project, the main dose of tritium is expected to be captured in the first wall, but there is a large surface area of stainless steel-vacuum chamber exposed to gaseous tritium after the plasma ignition. The prediction of tritium retention is today mainly calculated from data taken in a small system using similar parameters as expected for the ITER. Deuterium makes it possible to obtain valuable and complementary data on its retention in metals, but the high sensitivity in tritium detection can only be matched when pressure measurements and mass spectrometry are examined with the utmost care. In 2007 we investigated the kinetics of deuterium absorption and desorption in ITER-grade stainless steel at specified pressures and temperatures. The amount of retained deuterium could only be determined at a higher pressure (0.1 mbar) and temperature (400°C), when up to 5×10^{16} at. D/cm² was determined. It was noticed that the sensitivity of our method depends crucially on the regular hydrogen content prior to deuterium exposure. This conclusion may presumably be stated also for the amount of retained deuterium or tritium.

Field-emission (FE) characterization, together with two-terminal current-voltage measurements, was conducted inside a transmission electron microscope (TEM) equipped with a scanning tunnelling microscope (STM) sample holder. Inorganic nanowires were synthesized by the chemical transport reaction. They were manipulated and by electron-beam-induced deposition (EBID) of amorphous carbon (a-C) fixed to the tungsten tip inside the TEM. Preliminary field-emission characterization and two-terminal current-voltage measurements followed. In order to get an additional insight into the characteristics of the nanowires, a second experimental setup, a classic field-emission microscope, with a diode configuration designed for a point-to-plane geometry, was applied. Current-voltage relations, concurrent field-emission microscopy imaging, FE current stability (I/t), and reduced angular current density distribution could thus be obtained. It was found that the investigated inorganic nanowires represent a very bright point electron source comparable to carbon nanotubes.

It has been reported previously that relatively smooth nanocrystalline diamond films exhibit intense electron emission at low-to-moderate applied electric fields, which was in the past attributed exclusively to nanotips and nanotubes. Our task in 2007 was to determine the spatial distribution of the emission sites that originate from the surface of nanocrystalline diamond films. To characterize the relation of the emission sites over the whole surface, a triode concept has been developed that employs a pulsed voltage to the mesh and a dc potential applied to the luminescent screen to display the emission site distribution across the 20-mm-diameter substrates. Besides this method, a novel scanning field-emission microscope was constructed, where the applied field at the surface of the sample is uniform, and the electron emission from individual emission sites is projected onto the phosphor screen. In this way the emission current versus voltage for individual emitting sites was observed and characterized. This provided a fundamental insight into the relation between the materials' properties and the emission characteristics.

Some outstanding publications in the past three years

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2. A. Zalar, J. Kovač, B. Praček, S. Hofmann, P. Panjan, AES depth profiling and interface analysis of C/Ta bilayers, *Applied Surface Science*, 252 (2005), 2056–2062
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4. M. Mozetič, U. Cvelbar, A. Vesel, A. Ricard, D. Babič, I. Poberaj, A diagnostic method for real-time measurements of the density of nitrogen atoms in the postglow of an Ar-N₂ discharge using a catalytic probe, *Journal of Applied Physics*, 97 (2005), 103308-1–103308-7
5. V. Nemanič, B. Zajec, The influence of deuterium exposures on subsequent outgassing rate of an UHV system, *Vacuum*, 81 (2006), 556–561
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SEM image of paper after oxygen-plasma treatment A Vesel et al 2007
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Figure 4: A part of the flyer published by IOP Publishing to promote the *Journal of Physics D*. (Mag. 1000x).

Patent granted

1. Uroš Cvelbar, Miran Mozetič, Slobodan Milošević, Nikša Krstulović
Method and device for selective etching of composite materials by laser ablation, Patent No. 22288, Ljubljana, Urad RS za intelektualno lastnino, 2007.

Achievements

1. At the Twinmic x-ray microscope at the Elettra synchrotron light source we introduced, in collaboration with other European partners, a new method for imaging in scanning-transmission mode to measure fast and simultaneous images with absorption and phase contrast.
2. We have developed and patented an original method for the functionalization of vascular grafts that allows for an optimal adhesion of biocompatible coatings on the inner surface of the grafts.

Organization of conferences, congresses and meetings

1. 14th International scientific meeting on vacuum science and technology, Bled, Slovenia, June 2007 (Dr. Miran Mozetič, Dr. Janez Kovač, Dr. Vincenc Nemanič, members of International programme committee, Dr. Alenka Vesel, member of International organizing committee)
2. 12th European Conference on Applications of Surface and Interface Analysis, Brussels, Belgium, 9-14 September 2007 (Dr. Anton Zalar, member of International steering committee)
3. 43rd International conference on microelectronics, devices and materials, Bled, Slovenia, 12-14 September 2007 (Dr. Anton Zalar, member of Conference programme committee)

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Carbon monoxide oxidation on Au(111) surface decorated by spontaneously deposited Pt
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 32. Alenka Vesel, Miran Mozetič, Marianne Balat-Pichelin
Oxygen atom density in microwave oxygen plasma
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 33. Alenka Vesel, Miran Mozetič, Aleš Hladnik, Jožica Dolenc, Janja Zule, Slobodan Milošević, Nikša Krstulović, Marta Klanjšek Gunde, Nina Hauptman
Modification of ink-jet paper by oxygen-plasma treatment
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 34. Tjaša Vrlinič, Alenka Vesel, Uroš Cvelbar, Matjaž Krajnc, Miran Mozetič
Rapid surface functionalization of poly(ethersulphone) foils using a highly reactive oxygen-plasma treatment
In: Surf. interface anal., Vol. 39, no. 6, pp. 476-481, 2007.
 35. Danijela Vujošević, Miran Mozetič, Uroš Cvelbar, Nikša Krstulović, Slobodan Milošević
Optical emission spectroscopy characterization of oxygen plasma during degradation of Escherichia coli
In: J. appl. phys., Vol. 101, no. 10, pp. 103305-1-103305-7, 2007.
 36. Anton Zalar, Janez Kovač, Borut Praček, Peter Panjan, Miran Čeh
Ion sputtering rates of C, Cr, Zr, and Cr at different Ar⁺ ion incidence angles
In: Vacuum, Vol. 82, no. 2, pp. 116-120, 2007.
 37. Uroš Cvelbar, Miran Mozetič
Osnove fizike kisikove plazme
In: Vakuunist, Letn. 27, No. 1/2, pp. 24-33, 2007.
 38. Vincenc Nemanič
Fuzija - energija prihodnosti
In: Življ. teh., Leto 58, No. 4, pp. 30-38, apr. 2007.
 39. Anton Zalar
Trideset let spektroskopije Augerjevih elektronov v Sloveniji
In: Vakuunist, Letn. 27, No. 1/2, pp. 4-13, 2007.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Alenka Vesel
Fizika snovi
In: Fizika, moj poklic: življenje in delo naših fizičark, Marta Klanjšek Gunde, ed., Maja Remškar, ed., Marija Ipavec, ed., Nadja Zeleznik, ed., 1. izd., Ljubljana, Društvo jedrskih strokovnjakov Slovenije, 2007, pp. 70-71.

PUBLISHED CONFERENCE PAPERS

Regular Papers

1. Vincenc Nemanič, Bojan Zajec
Deuterium retention and release from tungsten
In: Conference proceedings, International Conference Nuclear Energy for New Europe 2007, Portorož, Slovenia, September 10-13, Igor Jenčič, ed., Melita Lenošek, ed., Ljubljana, Nuclear Society of Slovenia, 2007, pp. 803-1-803-8.
2. Alenka Vesel, Ita Junkar, Janez Kovač, Miran Mozetič
Activation of PTFE foil by treatment in oxygen and nitrogen plasma
In: Proceedings, 43th International Conference on Microelectronics, Devices and Materials and the Workshop on Electronic Testing, September 12. - September 14. 2007, Bled, Slovenia, Janez Trontelj, ed., Iztok Šorli, ed., Ljubljana, MIDE - Society for Microelectronics, Electronic Components and Materials, 2007, pp. 75-78.

PATENT APPLICATIONS

1. Uroš Cvelbar, Miran Mozetič, Slobodan Milošević, Nikša Krstulović
Method and device for selective etching of composite materials by laser ablation :
patentna prijava No. PCT/SI2007/000025
Ljubljana, ITEM d.o.o., Zastopniška pisarna za patente in blagovne znamke, 2007.
2. Miran Mozetič, Alenka Vesel, Uroš Cvelbar
Verfahren und Vorrichtung zur lokalen Funktionalisierung von Polymermaterialien :
patentna prijava No. 112006001297.5
München, Deutsches Patent- und Markenamt, 2007.
3. Miran Mozetič, Alenka Vesel, Ita Junkar, Uroš Cvelbar, Simona Strnad
Metoda in naprava za modifikacijo implantatov in umetnih žil iz PET polimera :
patentna prijava No. 200700263
Ljubljana, Urad RS za intelektualno lastnino, 2007.
4. Alenka Vesel, Miran Mozetič
Method and device for measuring ultrahigh vacuum
[S. l., s. n.], 2007.

B. SC. THESIS

1. Tjaša Vrlinič: Functionalization of polymer materials with highly reactive plasma

INTERNATIONAL PROJECTS

1. Erosion/Redeposition Characterisation in ITER-Revalt Divertor Tokamaks (TW6-1.3r3-TW6 G05) - T2-FU
EURATOM - MHST; 7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC, RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Vincenc Nemanič
2. Deuterium Retention and Release from Metal Surfaces - A Complementary Method to Nuclear Tritium Methods - P6-FU
EURATOM - MHST; 7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC, RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Vincenc Nemanič
3. Heterogeneous Surface Recombination of Neutral Hydrogen Atoms on Fusion Relevant Materials - P3-FU
EURATOM - MHST; 7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC, RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Miran Mozetič
4. Sensitive and Differential Blood and Cerebrospinal Fluid Test for Neurodegenerative Dementia Diagnosis
Innovation Projects Under the Sixth Framework Programme of the European Community
NeuroScreen, 6. FP
EC; Elodie Girardet, HLP Développement SA, Paris, France
Asst. Prof. Miran Mozetič
5. P6 - Deuterium Retention and Release from Metal Surfaces - A Complementary Method to Nuclear Tritium Methods
EURATOM - MHST; 6. FP, Fusion Association, EURATOM
FU06-CT-2004-00083, 3211-05-000017
EC, RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Vincenc Nemanič
6. P3 - Heterogeneous Surface Recombination of Neutral Hydrogen Atoms on Fusion Relevant Materials
EURATOM - MHST; 6. FP, Fusion Association, EURATOM
FU06-CT-2004-00083, 3211-05-000017
EC, RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Miran Mozetič
7. Safe Production and Use of Nanomaterials
NANOSAFE2, 6. FP; NMP2-CT-2005-515843
EC; Commissariat à l'Énergie Atomique, Grenoble, France
Marko Žumer, B. Sc., Asst. Prof. Maja Remškar, Andrej Detela, B. Sc., Prof. Boris Turk
8. Fullerene-based Opportunities for Robust Engineering: Making Optimised Surfaces for Tribology
FOREMOST, 6. FP, 515840-2
EC; Fundacion Tekniker, Eibar, Spain
Marko Žumer, B. Sc., Asst. Prof. Maja Remškar
9. Improving the Understanding of the Impact of Nanoparticles on Human Health and the Environment
IMPART, 6. FP, 013968
EC; Chalex Research Ltd., Torquay, Great Britain
Dr. Vincenc Nemanič, Asst. Prof. Maja Remškar

10. Vascular Graft Interfaces
VaGrint
ERA NET MNT, 3211-07-000024
University of Maribor, Faculty of Mechanical Engineering, Maribor, Slovenia
Asst. Prof. Miran Mozetič
11. Catalisators for Plasma Radicals
U1-BL-F4-84/06
Primož Eiselt, Plasmabull Engineering GmbH, Lebring, Austria
Asst. Prof. Miran Mozetič
12. Cleaning and Functionalization of Biocompatible Polymer Materials with Atmospheric Pressure Plasma
PROTEUS, BI-FR07-PROTEUS-002
Dr. Belmonte Thierry, Laboratoire de Science et Génie des Surfaces, Unité Mixte de Recherche CNRS 7570, Ecole des Mines, Nancy Cedex, France
Dr. Uroš Cvelbar
13. Characterization of Reactive Plasma
PROTEUS
Ph. D. Andre Richard, CPAT, Université Paul Sabatier, Toulouse, France
Asst. Prof. Miran Mozetič
14. Determination of N, O and H Radicals in Reactive Plasmas by Catalytic Probes and TALIF
BI-FR/06-PROTEUS-006
Prof. Freddy Gaborian, CPAT, Université Paul Sabatier, Toulouse, France
Asst. Prof. Miran Mozetič
15. Characterization of Plasma for Treatment of Biocompatible Materials
BI-HR/06-07-033
Dr. Slobodan Milošević, Institute of Physics, Zagreb, Croatia
Asst. Prof. Miran Mozetič
16. Planar Cold Cathodes Composed of Inorganic Nanowires
BI-CN/07-09-008
Dr. Lian-mao Peng, Institute of Physical Electronics, Peking University, Department of Electronics, China
Dr. Vincenc Nemanic
17. Nano-scale Phenomena Atop of Inorganic Nanotubes inducing Stable Field Emission
BI-CN/05-07/011
Dr. Lian-mao Peng, Institute of Physical Electronics, Peking University, Department of Electronics, China
Dr. Vincenc Nemanic
18. Experimental Measurements of Relative Sputtering Yields
BI-HU/06-07/007
Dr. Miklos Menyhard, Research Institute for Technical Physics and Materials Science, Budapest, Hungary
Prof. Anton Zalar
19. Surface and Coating Analyses of Samples
Universitaet Bayreuth FAN-C, Bayreuth, Germany
Dr. Janez Kovač
20. Research of Bacteria Damages after Plasma Radical Interaction
BI-SC/06-07-001
Asst. Prof. Dragan Laušević, Institut za zdravlje Crne Gore, Podgorica, Montenegro
Asst. Prof. Miran Mozetič
21. Large Scale Synthesis and Dispersions of Metal Oxide Nanowires
BI-US/06-07-002
Dr. Mahendra Sunkara, University of Louisville, Department of Chemical Engineering, Louisville, Kentucky, KY, USA
Asst. Prof. Miran Mozetič
22. Microscopic Characterization of Field Emission Sites on Nanostructured Carbon Films
BI-US/06-07-023

Prof. Robert Nemanich, North Carolina State University (NCSU), Department of Physics, Raleigh, USA
Dr. Vincenc Nemanic

R & D GRANTS AND CONTRACTS

1. Polymer nanocomposites for chemical sensors
Assistant Professor dr. Miran Mozetič
2. Highly reactive plasma for treatment of advanced composites
Assistant Professor dr. Miran Mozetič
3. Plasma sterilization and functionalization of biocompatible materials
Assistant Professor dr. Miran Mozetič
4. Electron beam writer with nanometric resolution
Dr. Vincenc Nemanic
5. Research of the integrated surge protective system
Dr. Vincenc Nemanic
6. Oxidation of metals by reactive oxygen plasma
Assistant Professor dr. Miran Mozetič
7. Field emission cathode from nanomaterials for THz miniature klystron
Dr. Bojan Zajec
8. Industrial intellectual rights as an instrument for economy development
Dr. Uroš Cvelbar
9. Self-cleaning photocatalytic paints and coatings
Assistant Professor dr. Miran Mozetič
10. Electron field emission from flat nanostructured cathodes
Dr. Vincenc Nemanic
11. Fusion relevant research and plasma surface interaction
Associate Professor Milan Čerček
12. Study of thin organic films and nanostructured materials by synchrotron radiation
Assistant Professor dr. Dejan Cvetko
13. Smart functional coatings for improvement of structures and components used in defensive purpose
Dr. Janez Kovač
14. Development of diagnostics for some edge plasma parameters in fusion devices
Associate Professor Milan Čerček

RESEARCH PROGRAMS

1. Vacuum technique and materials for electronics
Dr. Vincenc Nemanic
2. Thin film structures and plasma surface engineering
prof.dr. Anton Zalar

NEW CONTRACTS

1. Oksidation of metals with reactive oxygen plasma
Kolektor group d.o.o.
Assistant professor dr. Miran Mozetič
2. Plasma sterilization and functionalization of biocompatible materials
Induktio d.o.o.
Assistant professor dr. Miran Mozetič

VISITORS FROM ABROAD

1. Dr. Slobodan Milošević, Nino Čutić, Nikša Krstulović, Institute of Physics, Zagreb, Croatia, several times in the year
2. Dr. Primož Eiselt, Plasmabull, Lebring, Austria, several times in the year
3. Zoran Vratnica and Danijela Vujošević, Institute for health of Montenegro, Podgorica, Montenegro, several times in the year
4. Dr. Sabastian Brezinšek, dr. Marek Rubel, dr. Arkadij Kreter, Forschungszentrum Jülich, Jülich, Germany, 19- 22 February 2007
5. Burkhard Kaulich, Diane Dichert, Luca Gregoratti, Sincrotrone Trieste-Elettra, Italy, 8 March 2007

6. Dr. Jingyun Wang and dr. Zengquan Xue, University of Beijing, Beijing, China, 29.4.- 5.5.2007
7. Prof. dr. Thierry Belmonte, Laboratoire de Science et Genie des Surfaces, Nancy, France, 11-16 May 2007
8. Prof. dr. P. B. Barna, dr. G. Safran, Research Institute for Technical Physics and Materials Science, Budapest, Hungary, 12-15 June 2007
9. Dr. Francisco Tabares, Jose Antonio Ferreira, National de Fusion, Madrid, Spain, 23-30 July 2007
10. Prof. dr. R. J. Nemanich, North Carolina State University, Raleigh, USA, 15-17 September 2007
11. Dr. Cedric Noël, Rodrigo Perito Cardoso, Ecole des Mines de Nancy, France, 6-14 November 2007
12. Dr. Attila Sul yok, Laszlo Kotis, Research Institute for Technical Physics and Materials Science, Budapest, Hungary, 12-16 November 2007
13. Dr. Dragan Laušević, Institute for Health of Montenegro, Montenegro, 12-14 November 2007

STAFF

Researchers

1. Dr. Janez Kovač
2. Asst. Prof. Dr. Miran Mozetič
3. Dr. Vincenc Nemanic
4. Dr. Alenka Vesel
5. **Prof. Dr. Anton Zalar**, Head**

Postdoctoral associates

6. Dr. Uroš Cvelbar
7. Dr. Bojan Zajec

Postgraduates

8. Aleksander Drenik, B. Sc.
9. Kristina Eleršič, B. Sc.
10. Ita Junkar, B. Sc.
11. Tjaša Vrlnič, B. Sc.

Technical officers

12. Borut Praček, B. Sc.
13. Marko Žumer, B. Sc.

Technical and administrative staff

14. Ružica Bolte
15. Tatjana Filipič
16. Miha Kocmur
17. Janez Trtnik

Our research program is focused on the study of the structure and dynamics of disordered and partially ordered condensed matter at the atomic and molecular levels, with special emphasis on phase transitions. The purpose of these investigations is to discover the basic laws of physics governing the behaviour of these systems, which represent the link between perfectly ordered crystals, on the one hand, and amorphous matter, soft condensed matter and living systems, on the other. Such knowledge provides the key to our understanding of the macroscopic properties of these systems and is an important condition for the discovery and development of new multifunctional materials and nanomaterials for new applications. An important part of the research program is devoted to the development of new experimental methods and techniques in the field of magnetic resonance, magnetic resonance imaging, scanning tunnelling, electronic and atomic force microscopy, as well as dielectric relaxation spectroscopy and dynamic specific-heat measurements.



Head:
Prof. Igor Muševič

The experimental techniques used are:

- one (1D) and two (2D) dimensional nuclear magnetic resonance (NMR) and relaxation, as well as quadrupole (NQR) resonance and relaxation,
- multi-frequency NMR in superconducting magnets of 2T, 6T and 9T, as well as the dispersion of the spin-lattice relaxation time T_1 via field cycling,
- nuclear double resonance and quadrupole double resonance, such as ^{17}O -H and ^{14}N -H,
- frequency-dependent electron paramagnetic resonance (EPR) and 1D and 2D pulsed EPR and relaxation,
- MR imaging and micro-imaging,
- fluorescence microscopy and microspectroscopy,
- linear and non-linear dielectric spectroscopy in the range 10^2 Hz to 10^9 Hz,
- electron microscopy and scanning tunnelling microscopy,
- atomic force microscopy and force spectroscopy,
- dynamic specific-heat measurements.

Quasicrystals and complex metallic alloys exhibit “smart” properties, like thermal memory, a combination of an electrical conductor with a thermal insulator, a combination of hardness, elasticity and a low friction coefficient, and high capacity for hydrogen storage.

The research program of the Department of Solid State Physics at the “Jožef Stefan Institute” is performed in close collaboration with the Department of Physics at the Faculty of Mathematics and Physics of the University of Ljubljana. In 2006, the research was performed within three research programs:

- NMR and Dielectric Spectroscopy of Condensed Matter: Smart New Materials and Translational Symmetry Breaking,
- Physics of Soft Matter, Surfaces and Nanostructures,
- Experimental Biophysics of Complex Systems.

1. The program of the research group “**NMR and Dielectric Spectroscopy of Condensed Matter: Smart New Materials and Translational Symmetry Breaking**” was focused on investigations of the basic laws of physics of partially ordered condensed matter, as well as on the relation between the microscopic structure and dynamics of these systems and the macroscopic properties of matter with broken translational symmetry. We also developed new NQR and NMR techniques for the detection of explosives and polymorphism in pharmaceutical products. A European patent, Polarization enhanced two channel NQR/NMR detection of solid and liquid explosives using multi-pulse sequences, has been filed and two Slovenian patents were obtained. We also started the development of an optically pumped NQR spectrometer, which replaces a squid and promises much better sensitivity than classical NQR.

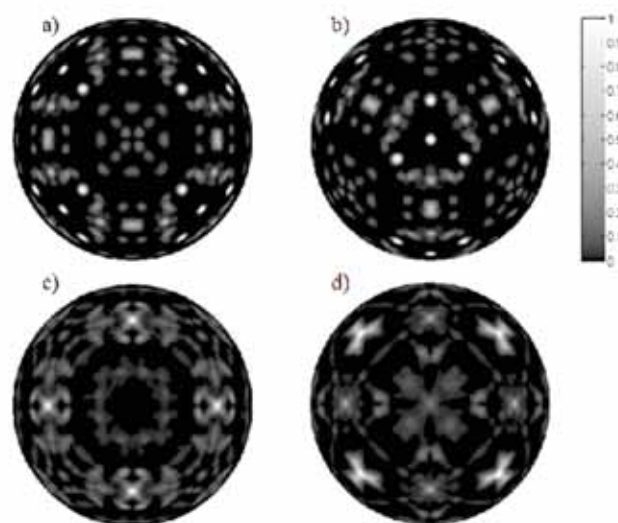


Figure 1: Distribution of electric field gradient tensors on a sphere in the Bergman phase Al-Mg-Zn (P. Jeglič and J. Dolinšek).

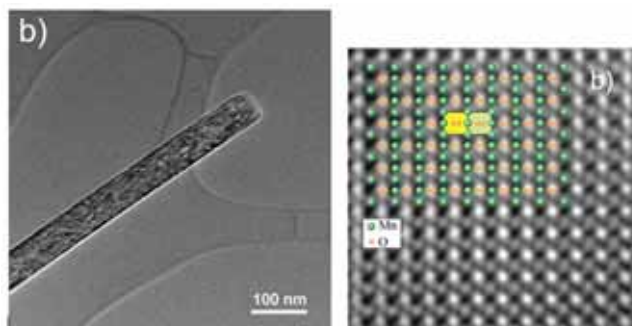


Figure 2: MnO_2 nanorods (morphology and structure), J. Dolinšek and colleagues.

In the field of **quasicrystals and complex metallic alloys** with a gigantic unit cell we have discovered new metallic phases of ϵ -Al-Pd (Mn, Fe, Co, Rh), that show a “smart” combination of good electrical conductivity and low thermal conductivity. This is an outstanding combination of transport properties, as it is common for most materials that are good electric conductors also to be good conductors of heat.

One of the major achievements of the NMR group in 2007 was a determination of the distribution of electric field gradient tensors in quasicrystals and complex metallic alloys. We developed a new method, where EFG tensors are extracted from the orientation-dependent NMR spectra of Al. The method enables extraction of the eigenvalues and principal directions of the EFG tensors. Such a distribution is shown in Figure 1., where the EFG principal directions in the unit cell of the Bergman phase Al-Mg-Zn are presented on a sphere [Phys. Rev. B 75, 014202 (2007) – P. Jeglič and J. Dolinšek].

Another important result was the synthesis, structure determination and magnetic properties of MnO_2 nanorods. The results represent the joint work of our group with Korean scientist from the Korea Basic Science Institute Daejeon. The work was published in Nanoscale Research Letters 2, 81 (2007) – J. Dolinšek and colleagues. The morphology and structure of the MnO_2 nanorods are shown in Figure 2.

In a continuation of our discovery [Nature (London), 441, 956 (2006) – Kutnjak, Blinc et al.] of electric-field-induced critical end points we investigated the angular dependence of the giant electromechanical effect in the PMN-PZT system. In the vicinity of the critical end points the difference between different phases disappears and the rotation of the electric polarization as well as ion displacements occur with rather small free-energy requirements. The resulting giant electromechanical effect is important for applications in sonars, acoustics, robotics, medicine and engineering. The results were also presented in an invited talk at the Meeting of the German Physical Society in Regensburg in March 2007. We have also performed the first determination of the 3D Born-Oppenheimer potential of a proton in the hydrogen-bounded superprotonic conductor $Rb_3H[SO_4]_2$. The results were published in Phys. Rev. Lett. 98, 115502-1-115502-4 (2007) – Blinc et al. A theoretical explanation for the Vogel-Fulcher law for a relaxor was found [Phys. Rev. B 76, 020101 (2007)]. Another important achievement is the discovery of the percolative ceramic composites, i.e., solid solutions of insulating and conductive perovskite ceramics that show critical phenomena in the vicinity of the percolation point.

Magnetolectric Systems, where the magnetic properties can be controlled by an electric field and vice versa, are important new materials for spintronic devices, new memory elements where the electric read out of magnetically stored information can be realized, and others. The bilinear magnetolectric (ME) effect is allowed in time and space asymmetric media. Here we report the first ME effect in systems without long-range order. Within the research of magnetolectric systems, three different lines of approach were used:

- A theory of magnetolectric effects in ferroic nanorods was developed. The intrinsic surface stress under the curved nanoparticle surface is shown to play an important role in shifting the ferroelectric and ferromagnetic transition temperatures and may induce a giant magnetolectric effect.
- The magnetolectric effect has been found in the ceramic $Pb(Fe_{1/2}Nb_{1/2})O_3$ – abbreviated as PFN – and shown to be of a quadratic nature. The site and charge disordered 0.8 PFN-0.2 PMW ceramic was shown to be a magnetolectric relaxor exhibiting a magnetolectric effect. The results demonstrate that both electric and magnetic nanodomains exist in this system and that the magnetolectric effect is due to coupling between the local nanocluster polarizations and magnetizations without any long-range order. This seems to be the first system where the magnetolectric effect has been found without any long-range order.
- The vast majority of known inorganic ferroelectrics and multiferroics are oxides. In cooperation with the Inorganic Chemistry and Technology Department (K1) we have started to investigate ferroelectric fluorides as potential multiferroic systems. We found weak ferromagnetism and ferroelectricity as well as a magnetolectric effect in polycrystalline and single-crystal $K_3Fe_5F_{15}$.

Within the study of local structures and the corresponding techniques the following results should be mentioned:

- The local structure of $BiFeO_3$ and Ni_2MnGa layers has been studied by electron paramagnetic resonance (EPR). In $BiFeO_3$ nanoparticles we found ferromagnetic spin-wave resonance.
- Ni_2MnGa is a Heusler alloy with a magnetic shape-memory effect. The ferromagnetic magnetic resonance intensity is so high that one can measure resonances even in monolayers.

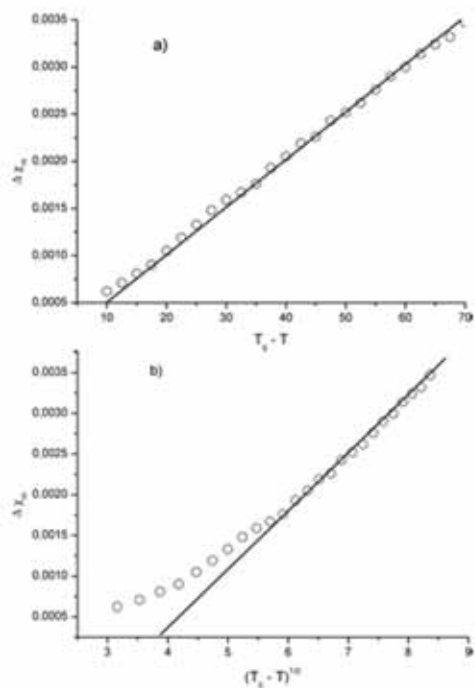


Figure 3: ME in PFN showing the relation between $\Delta\chi_m$ and P^2 below T_c . The results show that the relation between magnetization and polarization is quadratic. (a) Plot of $\Delta\chi_m$ vs $(T_c - T)$ and (b) Plot of $\Delta\chi_m$ vs. $(T_c - T)^{1/2}$. (R. Blinc et al.)

- Zero-field NMR of BiFeO_3 has been performed and the ^{209}Bi electric quadrupole coupling constant was found to be 312 MHz at 4 K.
- The local structure of piezoelectric $\text{Pb}(\text{Zr})_x(\text{Ti})_{1-x}\text{O}_3$ (abbreviated as PZT) nanotubes has been studied by EPR. The results show that we are probably dealing here with Jahn-Teller polarons.

In the field of **Liquid Crystal Elastomers**, the most important achievement was the discovery of crosslinker density-controlled critically of the paranematic-nematic phase transition in conventional side-chain systems [*Phys. Rev. Lett.* 99, 197801 (2007)]. Both *ac*-calorimetry and deuteron quadrupole-perturbed NMR experiments show that by increasing the concentration of crosslinking molecules, the thermodynamic response of conventional LSCEs can be promoted from below-critical to supercritical. These investigations also demonstrate that conventional networks are inherently disordered systems with random-field-induced smearing of criticality, manifested in distributed nematic order parameter values and weakly misaligned domains.

In 2007 members of the group published 52 original scientific papers in refereed international journals (Source: COBISS). The publications of members of the program were cited in 2007 altogether 1363 times and in the period 2004–2007 altogether 5858 times (Source: SICRIS). The leader of the program has – according to Web of Science – a Hirsch index of 47.

The above research was supported by the 6th framework European project MULTICERAL, where we are the local coordinators. In November 2007 the European Defence Agency (EDA) project GUARDED – where we are a partner – was signed. The active work will start January 31, 2008. We should also mention the annual organization of The European School in Materials Science in Ljubljana, which is one of the integration activities of the EU Network of Excellence “Complex Metallic Alloys” within the 6th Framework Program.

The research was also supported by numerous bilateral, industrial and defence projects.

In 2007 the members of the program organized the following international scientific meetings:

1. 2nd Euroschool in Materials Science, Mons, Ljubljana, May 21–26, 2007.
2. European Science Foundation (ESF) Workshop “Towards single spin physics”, Mons, Ljubljana, November 30, 2007.
3. 11th European Meeting on Ferroelectricity, EMF–2007, Bled, September 3–7, 2007.

In 2007, a memorandum of understanding and cooperation between the JSI and the Korea Basic Science Institute from Daejeon was signed. The initiative for that was given by our group and J. Dolinšek.

2. The investigations of the research program **“Physics of Soft Matter, Surfaces and Nanostructures”** were focused on novel soft condensed-matter systems and surfaces with novel and specific functional properties. Among them, we have investigated liquid crystalline elastomers and dendrimers as novel multifunctional materials, molecular motors, soft-matter photonic crystals and novel synthetic or self-assembled micro- and nanostructures. The aim of the program is to understand the structural and dynamic properties of these systems, their interactions, their function at the molecular level, self-assembly mechanisms in soft matter, as well as possible applications of novel phenomena. The underlying idea is that it is possible to understand complex mechanisms, such as self-assembly, on a macroscopic level, using a simplified physical picture and model systems. In this sense, the program combines experimental and theoretical investigations, modelling and simulations.

In the field of nematic colloids we have discovered the existence of entangled colloidal structures (Figure 5) in the nematic liquid crystal. This work was published in the paper “Entangled nematic colloidal dimers and wires”, *Phys. Rev. Lett.* 99, 247801 (2007). We have demonstrated that entangled topological defects in the form of loops and lines are responsible for the self-assembly of colloidal particles in the form of “colloidal wires” immersed in the liquid crystal. We have also found that the topological defect lines, which encircle one or several colloidal particles in the nematic liquid crystal, strongly attract smaller, submicrometer-sized colloidal particles and form necklace-like superstructures. Using conductive particles, such superstructures could be interesting for applications in metamaterials. We have also discovered that an external electric field has a strong influence on the lattice constant of 2D nematic colloidal crystals, which could lead to interesting applications in photonics.

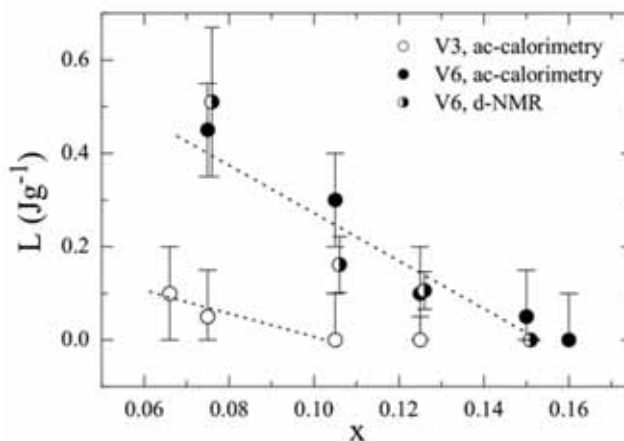


Figure 4: Experimentally observed trend towards supercriticality (vanishing latent heat L) on increasing crosslinking density (x) in conventional side-chain liquid crystal elastomers. (G. Cordoyiannis et al.)

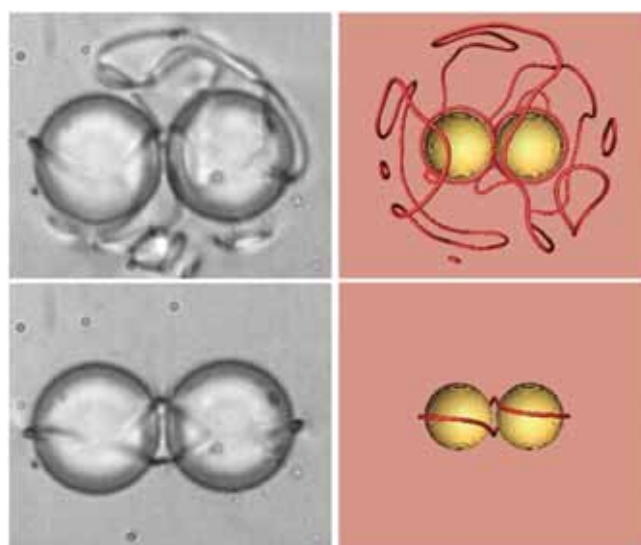


Figure 5. The creation of entangled nematic colloidal structures, which are bound by topological defects (dark lines). The image on the left is a microscope image, the image on the right is computer simulation using Landau-de-Gennes theory. (M. Ravnik et al.)

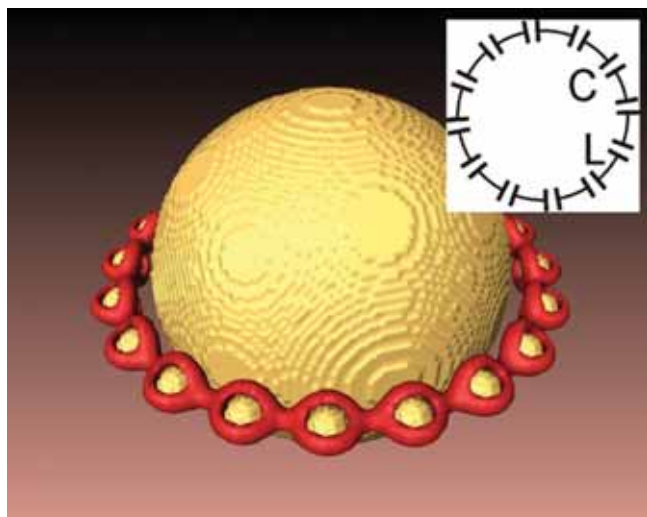


Figure 6: Computer simulation of the distribution of small colloidal particles in a Saturn ring encircling a large colloidal particle. For metal particles the system has the properties of the electric circuit shown in the corner. (M. Škarabot et al.)

We have investigated the influence of an external field on the position of a nematic line defect in a hybrid cell. We have studied the biaxial structure of the defect core and observed its expulsion from the cell. We have shown that under certain conditions the defect can broaden into a biaxial surface layer at a much lower field strength than with the defect-free cell. This result is important from a general perspective, since it shows that the presence of defects can significantly influence the critical values of external fields that trigger a structural transition. In addition, we conducted detailed experimental and theoretical investigations of the phase behaviour in mixtures of aerosol particles and liquid crystals at the smectic-A to smectic-C phase transition.

We made use of theoretical modelling in the quest for colloidal structures with a higher degree of complexity. We paid particular attention to the **entangled nematic defect lines** that bind together colloidal chains or 2-dimensional colloidal lattices. We have investigated the possibilities for hierarchic structures involving small and large colloidal particles. It appears that with a suitable choice of materials we can trigger the self-assembly of structures with metamaterial properties. Figure 6 shows a uniform distribution of small particles in a Saturn ring encircling a large colloidal particle. For metal particles, the system has the properties of the electric circuit shown.

We have developed a technology for improved-viewing-angle liquid-crystal optical shutters, based on “highly-twisted” structures of nematic liquid crystals. The technology allows for the production of eye-protecting goggles with superior optical performance, suitable for personal protection in medical applications. A set of optically complementary shutters is used, which enables a continuous attenuation of the external light and maintains a constant and angularly independent light level in the closed state. The light attenuation performance complies with the highest-quality international standard EN 379. We have successfully solved a series of rather sophisticated technological problems of the optical lamination of LCD shutters, compensating layers, passive IR/UV filters, etc. The technology has been transferred to the production in our spin-off company Balder d.o.o., which was the first company to offer the new generation of eye-protecting goggles on the world market.

In the field of **molecular motors** we have investigated how the motor protein myosin-V interacts with branched actin networks. On the basis of the elastic lever arm model we have studied the dynamics of the motor when it passes over a “y”-shaped filament junction, formed by the Arp2/3 complex. The calculated probability that the motor switches over to the side branch is in very good agreement with recent experimental results.

In the **Laboratory for Anorganic Nanotube Synthesis** we have synthesized fully novel forms of anorganic nanotubes, so-called “mama-tubes” (see Figure 8) and “nanobuds”. The former consist of MoS₂ nanotubes filled with anorganic fullerenes, whereas in the latter WS₂ fullerenes are attached to the surface of the nanotubes. These were the world’s first structures of this kind made of anorganic nanotubes and anorganic fullerenes. The chemical, physical and electrochemical properties of these materials are still completely unknown, but based on pre-existing

knowledge they appear promising. Because the nanotube walls are thinner than 20 nm, we can control the dosage of trapped fullerenes. This is the first step towards the concept of nanotribology. Hydrogen storage is a further potential application, since nanotubes with a far smaller inner volume have been shown to adsorb four times the amount of hydrogen as nanocrystals of the same compound do – even at relatively low pressures. The “mama-tubes” allow hydrogen adsorption between layers of fullerenes, as well as in the empty space between them. Within the scope of our work on airborne nanoparticle detection we have tested a new detection method and developed the second prototype detector in collaboration with the company CosyLab.

We have completed and successfully put into operation our new low-temperature ultra-high-vacuum STM (LT UHV STM) system, whose central part is the UHV cryostat, designed for the LT STM work. The new apparatus will be entirely devoted to the surface manipulation of single atoms and molecules. This year, on 6 July, our researcher Erik von Zupanič succeeded in assembling the logo of IJS, shown in Figure 9. We have therefore fully mastered the nanotechnology of atomic and molecular manipulation, which was proven by a number of experiments on Cu(111) and Cu(211) surfaces at temperatures below 10K. The second part of our work comprised



Figure 7. Balder - Yamamoto eye protective goggles for medicinal applications. Together with Japanese partner, Balder has commercialized protective goggles in 2006/07. (J. Pirš et al.)

experimental and theoretical studies of the electronic structure of quasi-one-dimensional compounds, this time in particular low-temperature angular-resolved photoelectron spectroscopy (ARPES) of ZrTe_3 , and the growth of NbSe_3 single crystals, large enough for LT STM measurements.

In 2007 our results were published in 25 articles in peer-reviewed journals and 2 contributions in international monographs. Four papers appeared in *Physical Review Letters* and one in *Advanced Materials*. Members of the programme group have given 9 invited talks at international conferences, and 2 European and 3 Slovenian patent applications were filed.

3. Within the program “**Experimental Biophysics of Complex Systems**” we explore processes and structures of various complex systems (from model systems to the structures in living cells, tissues and even small animals) including the effects of various bioactive molecules on these systems. One of the aims is to investigate the structural properties of different membrane structures such as membrane domains, membrane proteins and the glycosaccharide matrix as well as their interactions with other cell parts at different pathogenic states. These activities will improve our understanding of cell signalling and signal transduction in biomembranes, which in turn will enable better insight into complex cell responses. In addition, research in different fields is conducted, for example, in vivo oxymetry studies on live animals for optimization of medical treatment in tumour therapies, magnetic resonance imaging techniques and mathematical modelling of thrombolysis, magnetic resonance microscopy for application in forestry and wood science, studies of constrained diffusion as well as food processing by magnetic resonance imaging. Another important part of the activities is the development of spectroscopic methods of electron paramagnetic resonance, magnetic resonance imaging and combined fluorescence microspectroscopy. The latter will broaden the range of the used molecular spectroscopies in the group within the nanometre spatial and nanosecond time scale.

It has been found in the study of biomembrane structures that cholesterol and membrane domain structure has an important role in the interaction of delivering model vesicles and cancer cells. It was shown that the fluidity of membrane domains significantly affects membrane fusion as well as membrane adhesion and by that the malignancy of breast cancer cells. At the same time the presence of cholesterol in delivering liposomes strongly influences the interaction of their membranes with the membranes of cells, which can be exploited for the development of the directed transport of active substances, such as alkylphospholipids in the delivering membranes, to the cancer cells. It must be emphasized that the part of the research work in the past year was conducted not only by electron paramagnetic resonance but also with the infrared spectroscopy ATR-FTIR method in cooperation with a group from synchrotron Elettra in Trieste.

Development of the simulations of spin label conformation spaces in combination with SDSL EPR measurements leads to the research of a novel technique for the structural characterization of membrane proteins as well as other proteins, which cannot be successfully analyzed by classical high-resolution techniques. Within this work, a new possibility of the structural characterisation of intrinsically disordered proteins has been recognized. For example, the N-terminal part of the measles virus coat protein is disordered (and intrinsically unstructured) in the native state. However, when binding to its physiological partner P-protein, a part of the N-protein can achieve the structure of an alpha helix. As this is a very dynamic phenomena, EPR spectroscopy has been proved to be one of the rare applicable techniques, due to the appropriateness of its nanosecond time scale. With the application of simulations of the spin label rotational spaces on various protein sites we were able to perform different, very sensitive EPR characterizations with experiments done on a particular series of

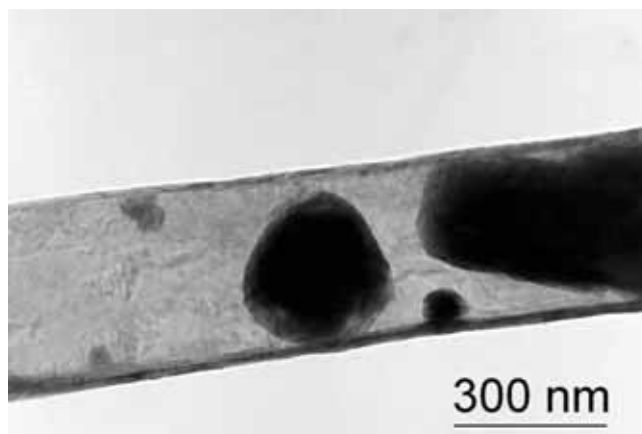


Figure 8: “Mama-tubes”: MoS_2 nanotubes, filled with inorganic fullerenes. (M. Remškar et al.)

On 6 July 2007 we succeeded in assembling the logo of the Jožef Stefan Institute, “IJS”, by manipulating individual Cu atoms on a Cu(111) surface, which was cooled to 9K, using a Scanning Tunnelling Microscope. The Jožef Stefan Institute has thus become a member of a very exclusive club of few laboratories in the world that are in possession of such a technology.

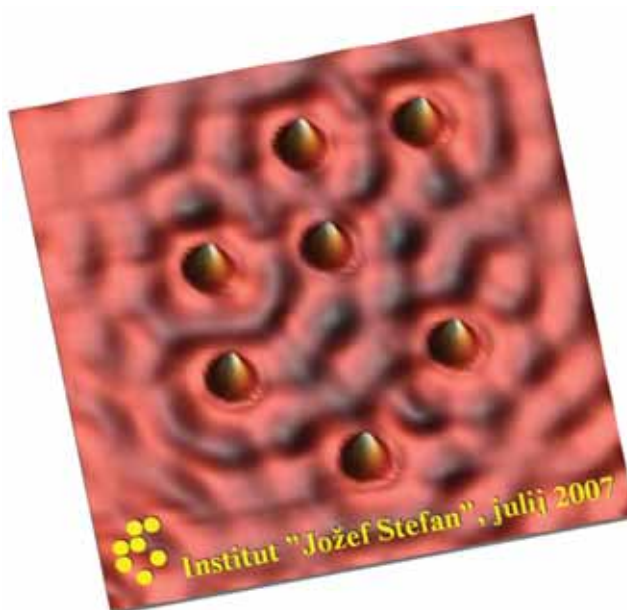


Figure 9: Logo of J. Stefan Institute, “IJS”, assembled by manipulating Cu atoms on a Cu(111) surface at 9K, using a low-temperature Scanning Tunneling Microscope, built at the JSI. (E. Zupančič et al.)

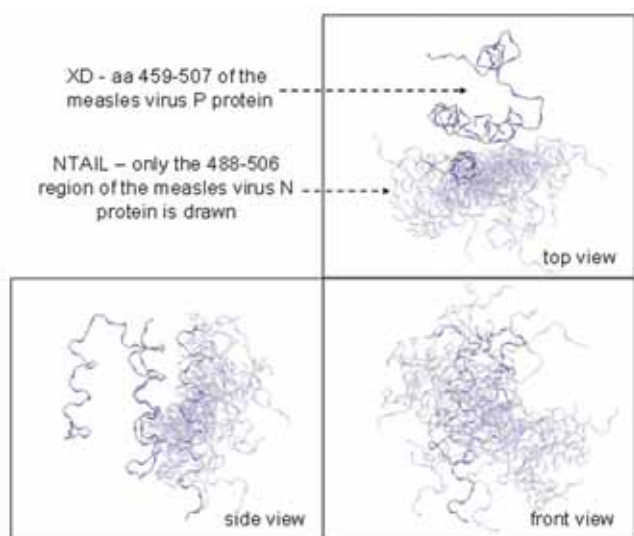


Figure 10: Interacting complex of measles virus N protein and XD part of P-protein. Various possible conformations of N protein are shown enlightened as determined from SDSL EPR data. (J. Štrancar et al.)

specifically spin labelled mutants of N-protein. With the help of simulations, possible conformations of an interacting complex have been determined, exposing some unexpected conformations, invisible to other high-resolution methods due to the experimental limitations.

With the same simulations we explain the spectroscopic results of activated spin-labelled mutants of human pancreatic lipase regarding a specific position on a protein lid that opens and closes the active site of the protein.

Different methods of deposition of titanate nanomaterials for the application in the maintenance of clean surfaces with photo catalysis has been investigated, in order to achieve the highest efficiency of their photo catalytic antimicrobial action on surfaces of selected materials. While studying the mechanism of the antimicrobial effect we have shown that oxygen and water molecules are necessary mediators of the energy transfer of the excited electron from the conducting band of a nanotube to a radical, which is capable of taking an electron in a bacterial electron transport chain and destroying a part of the bacterial metabolism.

At the same time we continued to work in the field of oxymetry and the effect of anaesthetics on the oxygen concentration in skin, which can have a significant effect on the efficiency of other tumour therapies.

Magnetic-resonance imaging (MRI) methods were used for an assessment of wood structure and its moisture content. Our interests were

primarily focused on the NMR relaxation-time properties in wood samples of different moisture content. As a result, we developed a correlation spectroscopy measurement method for assessing relaxation times, which helped us to assess the amount of water content in separate structures of the wood by using a multidimensional inverse Laplace transformation. In order to image dry wood, we also developed a method for imaging samples with short T₂ relaxation times. MRI was also used for assessing thrombolysis in *in vitro* model clots. In order to mimic the physiological conditions of clot dissolution, we set up a new perfusion system generating pulsatile flow. Our interests were also focused on measuring the relaxation-time properties of model blood clots with various hematocrit ratios and with platelet-rich regions. Based on these results, our future goal is to establish a clinically relevant protocol for assessing the lysability of thrombi by using high-resolution MR imaging. Furthermore, by numerical methods we modelled the penetration of the thrombolytic agent into the clot during thrombolytic therapy. We also used NMR to assess the diffusion spectra of different materials. A new method for measuring diffusion spectra with excellent stability and with a wide frequency range was developed as well. Besides the new method, a new RF coil was built for measuring temperature-dependent diffusion, which can produce strong magnetic field gradients that are inevitable in precise diffusion measurements. The influence of radiation in biological systems was studied by detecting the metabolic changes with ³¹P NMR spectroscopy in groups of mice exposed to different levels of irradiation. MRI was also used for testing the use of paramagnetic nanoparticles as a possible future MRI contrast agents. Nanoparticles seem to represent an alternative to the most frequently used contrast agent nowadays, Gd-DTPA, since they are much smaller and they accumulate more efficiently in tumour cells in their early stages.

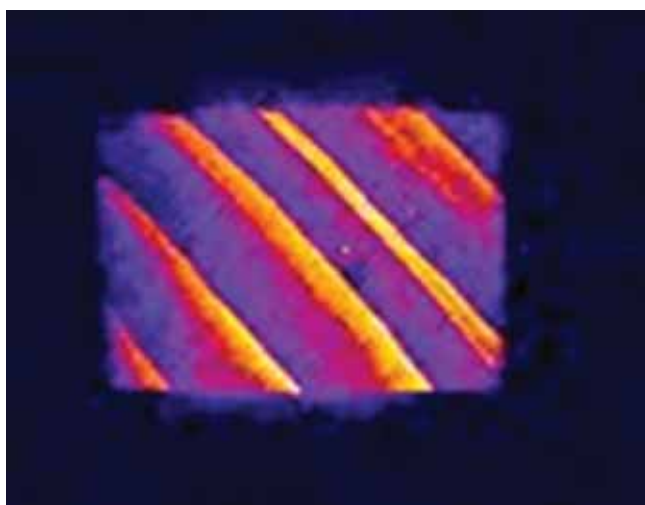


Figure 11: MR image of a dry wood sample with a 10% moisture content (T₂ = 230 μs). (U. Mikac et al.)

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Awards and appointments

1. Robert Blinc: Honorary member of JSI, Ljubljana, JSI
2. Robert Blinc: "Gold Medal of the IPS", Ljubljana, International Postgraduate School
3. Marko Viršek: YUCOMAT 2007 Award for Best poster, Herceg Novi, Montenegro, Yugoslav Materials Research Society (Yu-MRS)

Organization of conferences, congresses and meetings

1. FOREMOST (Fullerene-based Opportunities for Robust Engineering: Making Optimised Surfaces for Tribology), IJS Ljubljana, 10. 10.–12. 10. 2007
2. EMF-2007 ("11th European Meeting on Ferroelectricity"), Bled, 3.–7. 9. 2007
3. 2nd European School in Materials Science, MONS, Ljubljana, 21.–26. 5. 2007
4. European Science Foundation (ESF) Workshop "Towards single-spin physics", MONS, Ljubljana, 30. 11. 2007
5. F5 department brainstorming day, Bistra, 17. 10. 2007

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3. Janja Goršek: Osmotic volume changes in human erythrocyte due to effects of Hg^{2+} , Pb^{2+} and Cd^{2+} on membrane channels (Gojmir Lahajnar)
4. Matjaž Humar: Behavior of two-dimensional nematic colloidal crystals in the presence of an electric field (Igor Muševič, co-mentor Miha Škarabot)
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2. Synthesis and Characterization of Electromechanically Active Composites of Mesogenic Elastomers and Electrically Active Nanoparticles
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Prof. Janez Dolinšek, Dr. Peter Panjan, Prof. Spomenka Kobe
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EC; Frederic Schuster, Commissariat a l'Energie Atomique, Grenoble, France
Asst. Prof. Maja Remškar
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Asst. Prof. Maja Remškar, Marko Žumer, B. Sc.
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IMPART, 6. FP
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EC; Mark Pullinger, Chalex Research Ltd., Torquay, Great Britain
Asst. Prof. Maja Remškar
8. A Quadrupole Resonance Instrument for the Clearance of Abandoned Minefields
NATO SFP - Minefield Detection
NATO SFP - 978007
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NATO Scientific Affairs Division; Prof. J. A. S. Smith, King's College London, Chemistry Department Strand, London, Great Britain
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COST P15, EC
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11. Multidisciplinary Frontiers of Magnetic Resonance
EMAR
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12. Microscopy and Magnetic Resonance Study of Derivatized One-dimensional Titanate-based and Carbon Nanostructures and Their Adsorption Potential Toward NO₂
PROTEUS, BI-FR07-PROTEUS-007
Dr. Alexandre Gloter, Laboratoire de Physique des Solides CNRS UMR 8502, Université Paris-Sud, Laboratoire de physique des Solides, CNRS UMR 8502-Université Paris-Sud, Orsay, France
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13. Novel Soft Matter with Unusual Optical and Physical Properties: Nanostructured Liquid-crystal Microemulsions and Elastomers
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14. Novel Solid-state Intermetallic Materials for Hydrogen Storage and Advanced Characterizations
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RESEARCH PROGRAMS

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NEW CONTRACTS

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Balder d.o.o.
Dr. Janez Pirš
2. Expert opinion on automatic LCD light shutters
Balder d.o.o.
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3. Artificial nose
Ministry of defence
Prof. Igor Mušević

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2. prof. dr. Chris Smith, School of Engineering and Computer Science, University of Exeter, Exeter, Devon, Great Britain, 31. 1.-2. 2. 2007
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5. dr. Hwanuk Kim, Korea basic Science Institute, Daejeon, S. Korea, 23. 3. - 26. 3. 2007
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27. dr. Dmitry Pelegov, Institute Physics & Applied Materials, Ural State University, Ekaterinburg, Russia, 31. 8.-2. 9. 2007
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31. prof. Valentin Laguta, Institute for materials Science, Moscow, Russia, 30. 8.-15. 10. 2007
32. prof. dr. Naresh Dalal, Department of Chemistry and Biochemistry, Center for Magnetic Resonance, National High Magnetic Field Laboratory, Florida State University, Tallahassee, Florida, USA, 5. 9.-6. 9. 2007
33. Evangelia Karatairi, NCSR Demokritos, Aghia Paraskevi, Greece, 9. 9.-30. 9. 2007
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39. dr. Michal Bielejewski, Institute of Molecular Physics, Poznan, Poland, 15. 10.-21. 10. 2007
40. Andrey Enyashin, Institute of Physical Chemistry, Technical University Dresden, Dresden, Germany, 10. 10.-12. 10. 2007
41. mag. Uliana Ognysta, Institute of Physics, National Academy of Sciences (NAS) of Ukraine, Kyiv, Ukraine, 28. 10.-27. 11. 2007
42. prof. dr. Maya Glinchuk, Institute for Problems of Materials Science; NAS of Ukraine, Kiev, Ukraine, 10. 11.-10. 12. 2007
43. prof. Alan C. Seabaugh, University of Notre Dame, Department for Electrical Engineering, Indiana, USA, 21. 10.-31. 10. 2007
44. dr. Michael Rappolt, Sincrotrone Trieste, SAXS Beamline, Trieste, Italy, 13. 11. 2007
45. Maureen McCamley, Brown University, Providence, USA, 15. 11. 2007
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47. prof. Yishay Manassen, Ben Gurion University, Beer Sheva, Israel, 1. 12.-7. 12. 2007
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49. dr. Pedro Sebastiao, Technical University, Lisbon, Portugal, 2. 12.-7. 12. 2007
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52. prof. Mladen Horvatič, CNRS Grenoble, Grenoble, France, 6. 11.-9. 11. 2007
53. prof. dr. Malcolm Heggie, University of Brighton, Brighton, UK, 11. 12.-14. 12. 2007

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DEPARTMENT FOR COMPLEX MATTER

F-7

The research within the Department of Complex Matter encompasses a variety of research fields, ranging from the synthesis of new materials to fundamental investigations of the elementary excitations in complex systems. These include anything from nano-biosystems and biomolecules to superconductors and nanowires. The experimental methods used are suitably diverse, from synthetic chemistry to biomedicine and femtosecond laser spectroscopy to magnetometry. Last year's research achievements are thus quite diverse.



Head:
Prof. Dragan D. Mihailović

The activities in the department can be grouped together into a number of thematically inter-related research areas:

Ultrafast studies of electron dynamics in different systems

The field of research on the relaxation processes of photoexcited electrons in strongly correlated electron systems remains one of our main research topics. Several experimental studies of carrier relaxation phenomena in strongly correlated electron systems have been performed using femtosecond time-resolved techniques. The aim of the ongoing research is to gain additional information about the nature of the low-lying excitations in these materials, and to explore the nature and strength of the interactions of electrons with other low-lying excitations.

As an important contribution to the understanding of the nature of the pairing in high-temperature superconductors we should point out our study of relaxation processes in the cuprate superconductor $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$. The research focus was on the dynamics in the high-excitation regime utilizing high-energy optical pulses from a Ti:sapphire amplifier. Since the optical pulse energy is high enough to completely suppress the superconductivity, we were able to accurately determine the absorbed energy density required to completely suppress the superconductivity. Interestingly, this absorbed energy density is more than an order of magnitude higher than the thermodynamically measured condensation energy. This fact implies that following the photoexcitation most of the energy is stored in a bosonic subsystem. By performing a detailed study of all the possible relaxation channels, we could conclude that the only possible candidates for the bosonic subsystem are lattice excitations. This suggests that high-frequency phonons are responsible for pairing in the cuprates. The paper is currently under review in Physical Review Letters.

We have performed systematic measurements of photo-induced absorption (PIA) in LaSrAlO_4 . While this material is potentially interesting for the development of an all-solid-state laser, the main motivation for studies of the PIA stems from the fact that PIA in near-infrared seems to be characteristic for oxide systems, including high-temperature cuprate superconductors. At low temperatures we have observed strong PIA centred at around 0.7 eV. By performing systematic studies, varying the excitation density, the density of the near-infrared light, the temperature and the concentration of the oxygen defects we have found that the strong PIA in the near-infrared is due to the trapping of photo-excited carriers near oxygen defects. This work has been published in Physical Review B 76, 054304 (2007).

We studied the equilibrium and non-equilibrium optical properties of $\text{Mo}_6\text{S}_3\text{I}_6$ nanowires. By means of opto-acoustics we have measured the propagation of sound in a random $\text{Mo}_6\text{S}_3\text{I}_6$ nanowire network for the first time. The pump-probe technique allows us to measure the reflection of an optical pulse from a propagating acoustical disturbance in spite of very high sound damping in the rather porous network medium. We used a range of different laser wavelengths, from 0.7 to 2.4 μm , and a measurement of the refractive index, to obtain a value of the sound velocity.

The absorption of oriented thin films of $\text{Mo}_6\text{S}_3\text{I}_6$ nanowires shows good qualitative agreement with density functional theory calculations (in collaboration with department F1). The broad features indicate the large density of interpenetrating electron sub-bands as well as the damping of transitions and the disorder in the bulk. The electron relaxation from a non-equilibrium situation was explored with femtosecond pump-probe spectroscopy. We found a cascade relaxation involving three distinct states determined the lifetimes of these states, which cover the ranges from a hundred fs to a ns. We are currently examining the electronic nature of these states with further spectroscopic methods, such as electromodulation. Some of these results are already published in Phys. Stat. Sol. B 244, 4152 (2007) and J. Appl. Phys., 102, 013510-1 (2007).

In order to break away from the current limitations in molecular electronic circuit design, a new method needs to be invented for the connection of single-molecule devices to the outside world. The connection needs to be made reliably, using covalent bonds and with simple high-yield self-assembly protocols.

The two-dimensional $R\text{Te}_3$ family ($R = \text{Ho, Dy, Tb}$) with its charge-density wave (CDW) ordering was studied with ultrafast spectroscopy. In the responses both the collective (i.e., the amplitude mode) and single-particle excitations were observed. It was shown that in the HoTe_3 compound below the phase transition to the 2-dimensional CDW state at $T_{c2} = 126$ K, which is characterized with two different wavevectors, two oscillatory modes are observed with the frequencies 2.133 THz and 1.740 THz at 10 K. The first disappears above the 2-dimensional CDW phase-transition temperature, while the second persists up to the 1-dimensional CDW transition temperature at $T_{c1} = 286$ K. This observation can presumably be interpreted as the coexistence of two amplitude modes below the 2-dimensional CDW phase-transition temperature. An analysis of the single-particle dynamics allowed us to estimate accurately the values of the CDW gaps of the compound.

The time-resolved Magneto-optical Kerr effect (TRMOKE) in the insulating ferromagnetic phase in $(\text{Pr Ca})\text{MnO}_3$ thin films on different substrates was measured as a function of temperature in magnetic fields up to 1.1T. The photo-induced Kerr rotation and ellipticity show a remarkably different magnetic-field dependence. From a comparison with the static Kerr rotation and ellipticity we concluded that two different magnetic phases are present in the samples at low temperatures. A comparison of the temporal dependence of the photo-induced Kerr signals with the photo-induced reflectivity indicates that upon photo-excitation changes to the volume fraction of these phases take place on a timescale of a few tens of picoseconds. A paper on this subject is currently in preparation.

Theoretical studies on the nanoscale

On the basis of extensive Monte-Carlo simulations of the lattice-gas model with competing anisotropic Jahn-Teller and isotropic Coulomb interactions we formulated a phenomenological theory of the Coulomb-frustrated first-order phase transition. An analysis of this model was extended to the case of the second-order phase transition. It was shown that the Coulomb interaction leads to similar effects of the phase separation in the case of the second-order phase transition. (Physical Review B, 76, 054523 (2007)).

After a prediction of the new frequencies in the de Haas-van Alphen oscillations of the metallic nanowires we investigated the stability of the effect and the influence of different boundary conditions. We also discuss the possible constraints on the experimental detection of the effect. We found that the additional mixture of frequencies is possible due to a chemical potential oscillation in the low-dimensional systems (Physical Review B, 76, 155417 (2007), *ibid* 76, 233101 (2007)).

We have shown that the additional reduction of the symmetry of the order parameter in the mixed state of the type-II singlet superconductors is caused by the application of a magnetic field. This effect may lead to the appearance of the inhomogeneous helical states in superconductors. Criteria for the experimental observation of this effect were also formulated. (Physical Review B, 76, 172501 (2007)).

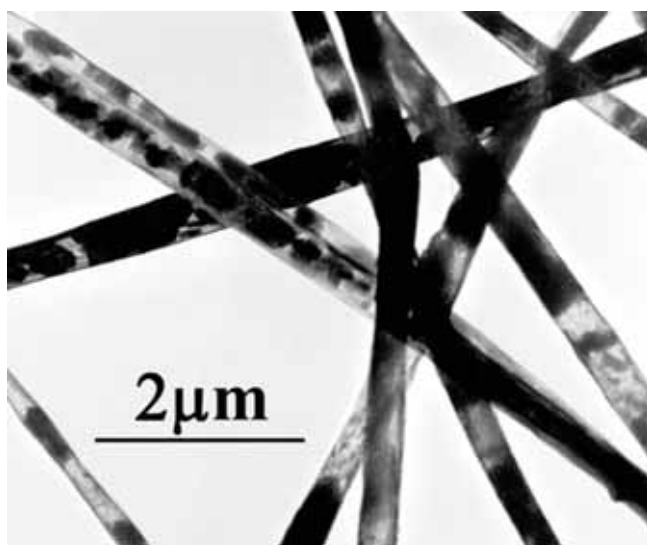


Figure 1: Transmission electron micrographs of the final product: - a general view of the MoS2 nanotubes with encapsulated MoS2 fullerene-like nanoparticles. (foto: Asst. prof. Maja Remškar).

Nanotubes and nanomaterials

The magnetic properties of high-purity stoichiometric La_2CuO_4 nanoparticles were systematically investigated as a function of particle size. Ferromagnetic single-domain spin clusters were shown to form spontaneously at the surface of fine grains as well as paramagnetic defects. Hysteresis loops and thermomagnetic irreversibility were observed across a wide temperature range, 5–350 K, where the remanent moment and coercivity gradually decrease with increasing temperature. Possible origins of the spontaneous surface ferromagnetic clusters and the relation of our data to the appearance of unusual magnetic phenomena and phase separation of doped cuprates were discussed. The results were published in Physical Review B 76, 024428 (2007).

Molecular electronics forms an important part of the work in the department, focussing on the properties of our MoSI nanowires. The electrical conductivity and chemical properties make it uniquely important as a building block in molecular electronics. Thus a large effort has been placed on determining properties such as the intrinsic mechanism for conductivity and other physical properties. A breakthrough has been made in connecting diverse elements, such as individual molecules, gold nanoparticles and individual nanowires together by self-assembly on a large scale.

In a focussed effort, the structure of $\text{MoS}_{4.5}\text{I}_{4.5}$ was determined using advanced electron microscopy techniques. The structural determination of the individual nanowires represents a breakthrough in the accurate structural determination of nano-sized objects that exhibit a lot of local deformations, substitutional defects and disorder, preventing the determination of site occupancies by standard techniques, including XAFS, PDF and XRD. This work, which was published in Advanced Materials, was performed in collaboration with partners at Trinity College Dublin and Oxford University, amongst others.

The non-linear optical properties of MoSI nanowires have been investigated to determine the possibility of using them as optical limiters. In a paper that recently appeared in Chem. Phys. Letters, we compared the optical limiting behaviour of MoSI nanowires with carbon nanotubes, discussing the potential advantages at certain important optical wavelengths. Such optical limiters have found use in portable mode-locked solid-state lasers. Optical limiters based on MoSI nanowires offer the potential for operation at other wavelengths. The work was performed in collaboration with TCD within the scope of the DESYGN-IT project.

MoSI nanowires have been grown on Mo metal and quartz substrates in order to investigate their potential for large-area field-emission devices such as displays and lighting. The growth on Mo metal surfaces was particularly important because it was possible to achieve the sparse growth characteristics necessary to achieve efficient field-emission properties. The contact between the Mo substrate was found to be excellent and the FE emission properties were found to be comparable or superior to similar state-of-the-art devices based on carbon nanotubes. This work appeared in the Journal of Applied Physics.

MoSI nanowires represent a very important system for investigating low-dimensional physics. Their very weak interwire forces make them extreme one-dimensional systems. In collaboration with CRTBT at Grenoble and the Institute for Physics in Zagreb the low-energy excitations were investigated using specific heat measurements at very low temperatures. In a paper we described the effects of the extreme 1D behaviour on the low-energy excitations in this material.

An extended and elaborate effort was made to investigate the optical properties of MoSI nanowires using a number of complementary techniques, and these are reported in Physical Review B. The optical absorbance from far infrared to UV was measured in thin films and in solution. The results were compared with the optical conductivity obtained from reflectivity measurements made at ETH in Zurich. The experimental work was supplemented with detailed theoretical calculations of the optical properties of MoSI nanowires based on DFT calculations performed by Igor Vilfan (department F1).

The dispersion characteristics of MoSI nanowires are of great importance for their potential use in virtually all applications considered so far. Their dispersion properties are described in detail in two papers by McCarthy et al, in the J. Appl. Phys. and the Eur. J. Appl. Phys. The work was done within the scope of the EU DESYGN-IT project.

In 2007 we reported on a new synthesis method to enable the production of gram quantities of MoS₂-like fullerene structures, MoS₂ nanotubes and MoS₂ nanotubes filled with MoS₂ fullerenes – MoS₂ peapods. Nanowires based on Mo₆S₂I₈ are used as precursor crystals and have been sulfurized at 1100 K in flowing Ar gas containing 1% of H₂S and 1% of H₂. The total mass of the starting material during the two-hour process decreased by 40% due to the complete removal of iodine. X-ray powder diffraction and x-ray energy-dispersive analysis of the end product revealed an I-free MoS₂ compound. The morphology of the nanowires was preserved, but slightly modulated in diameter. The nanotube walls were relatively thin, only a few tens of nanometers, while some fullerene-like particles exceed several hundred nanometers. Spherical MoS₂ nanoparticles, with a low degree of agglomeration, grow in the confined geometry of nanotube reactors; these reactors serve afterwards as nanocontainers. The fullerene-like particles are generally hollow with high concentrations of lattice defects, which cause deviations from the spherical shape. The described synthetic route based on Mo₆ clusters may apply to other transition-metal clusters in combination with different chalcogenides to give rise to a new chalcogenide-nanotube technology. Is it possible to form homogeneous or heterogeneous inorganic fullerenes or other nanomaterials encapsulated inside the nanotubes? Nanoparticles created in this way are protected against release into the atmosphere, avoiding some potential health risks; they are kept against spontaneous agglomeration, which renders improved control of the size distribution, which is effectively limited by the inner nanotube diameter. The peapod structure represents a promising technology for the safe production and transport of nanomaterials with a preserved original size distribution. Relatively simple synthesis, which can be upgraded for the bulk production of inorganic peapods and the existence of a wide variety of available and promising precursor crystals, opens up many exciting possibilities.

In a paper published in Nanoletters, we have shown an entirely new approach that uses inorganic molecular conducting wires with built-in sulfur atoms at the ends. By happy coincidence sulfur is also the most commonly used connecting element in molecular electronics. Marrying the two together seems a perfect match, and indeed the experiments shown here represent a crucial step with remarkably high success rates, giving real promise of realising self-assembled molecular-scale circuits.

Electron dynamics in biological macromolecules

In 2007 we continued our study of electronic transitions in *M*-DNA, a new form of DNA where divalent metal cations are incorporated into the DNA structure by replacing one of the hydrogens from the hydrogen bonds in the interior of the double helix. We have found that the intercalation of metal ions into the DNA double helix alters the DNA's electronic structure, which is observable in its optical spectra. By measuring the optical absorption spectra of *M*-DNA and comparing them with the corresponding spectra of pristine DNA we found that the HOMO-LUMO gap decreases by ~0.1 eV. The HOMO-LUMO gap decrease is presumably caused by structural changes in the *M*-DNA

double helix, induced by the intercalated metal cation. These structural changes promote the π - π overlap between the molecular orbitals of neighbouring nucleobases and consequently increase the energy bandwidths. We expected that the increased interaction between the nucleobases would affect the *M*-DNA emission spectra even more. Therefore, we have started with comparative measurements of DNA and *M*-DNA fluorescence spectra. It turns out that besides a 50% decrease in fluorescence intensity with a maximum at 325 nm, the spectrum of *M*-DNA shows a broad emission peak centred at 430 nm, which is not observable in pristine DNA. A comparison with the low-temperature emission spectra of DNA and a control experiment where we have quenched the broad long-wavelength emission of *M*-DNA by adding paramagnetic Mn^{2+} ions suggest that the long-wavelength emission of *M*-DNA could be related to phosphorescence. The origin of the phosphorescence is a radiational relaxation from an excited triplet state. A transition to the triplet state is forbidden in optical transitions without additional interactions. Hence, DNA phosphorescence is very weak and could be observed only at low temperatures (77 K). But, in the case of *M*-DNA we have an example of a heavy-metal ion in proximity to the π electron system of the nucleobases, which could create a so-called heavy-atom effect. The heavy-atom effect is an effect where an atom with a high atomic number Z strongly increases the spin-orbit interaction of π electrons, which is a required magnetic perturbation for singlet-to-triplet transitions and, consequently, phosphorescence. Phosphorescence of *M*-DNA is the first example of phosphorescence observed in DNA or DNA-related structures at room temperature and close to physiological conditions and it could have an important impact on future research on DNA triplet states.

In the **Light and matter** research group we continued our interdisciplinary studies of the interaction of light and matter and its use in research and applications in different fields.

Soft Matter

We studied nematic colloids and used magneto-optical tweezers to measure the forces between two particles with tangential anchoring at the surface. Due to elastic deformations in the nematic liquid crystal, the interparticle interactions are of long range. We concentrated on the influence of the confining surface on the interactions and first results show that when the wall-to-wall separations between the particles are comparable to the sample thickness, screening effects occur. The results were compared with a theoretical model made at the University of Ljubljana, Department of Physics, and good agreement was found. A paper is in preparation.

In cooperation with the Nonlinear Physics Group (NLP) at the Faculty of Physics, University of Vienna, (Austria) we continued investigations of the diffraction properties of holographic polymer-dispersed liquid crystals (HPDLCs). The effect of an applied external electric field on holographic scattering in the 1D transmission gratings was analyzed. The results were published in *Optical Materials* 29, 1416-1422 (2007). We also studied the effects of spontaneous processes, which occur in the dark after photopolymerization, on the structural and diffractive properties of the gratings. It was observed that significant "dark modifications" of the structure take place several days after the termination of the illumination and produce large modifications of the diffraction efficiency. A new series of optical gratings with different grating periodicities was fabricated and a comparative study of their diffraction properties was accomplished. The diffraction properties were reported in *Proc. SPIE Vol. 6587, 65870F-1-6* (2007).

In cooperation with the Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences, we started cooperative investigations of 2D composite photonic structures from polymers and liquid crystals. With the help of an interference pattern of four coherent laser beams that were mixed on the sample with the help of a special glass pyramid, we fabricated a 2D photonic lattice with four-fold rotational symmetry. The role of the Nematic-Isotropic phase transition and the effect of the external electric field on the structural and diffraction properties of the lattice were investigated.

In cooperation with Brown University (Providence, USA) we investigated the structural and diffraction properties of holographic gratings with ferroelectric liquid crystals (HPDFLCs). The emphasis was on the analysis of the optical second-harmonic generation (SHG), which is specifically related to the existence of the smectic C^* phase in these materials. The angular and polarization dependencies of the non-linear Bragg reflection were analyzed. Dynamic light-scattering measurements of the thermal orientational fluctuations of the liquid crystal phase embedded in various HPDLCs were performed and the obtained results were reported in *Phys. Rev. Lett.* 98, 173901-1-4 (2007).

We continued our research on the self-assembling properties of guanosine derivatives, especially guanosine 5' monophosphate (GMP), deposited onto mica and silicon substrates. The analysis of surface adsorbates was performed by atomic force microscopy (AFM). It was found that under the appropriate deposition conditions, the GMP on mica forms G4-nanowires, which can be several micrometers long and exhibit a profound directional growth along the crystallographic axes of the substrate. The results were published in *Colloids and Surfaces B: Biointerfaces* 59, 120-127 (2007). In cooperation with the University of Bologna (Italy) we started an investigation of Langmuir-Blodgett films of lipophilic guanosine derivatives.

Our cooperation with the laser company Fotona d.d. was focused on the further development of computer-simulation methods for determining the optical field in unstable laser resonators. The main part of the work was devoted to resonators with Gaussian mirrors and to investigations of the self-Q-switching effect in Ruby lasers. The results were reported in *Proc. SPIE Vol. 6584, 65840I-1-7* (2007).

We have studied the anisotropy of light diffusion in polymer-dispersed liquid crystals (PDLCs). The anisotropy of the diffusion of light was experimentally first observed in bulk nematic liquid crystals. The origin of the anisotropy in such a system is due to the optical anisotropy of a nematic liquid crystal and to the anisotropic scattering of light from nematic orientational fluctuations. In PDLC anisotropic scatterers, i.e., nematic droplets, are embedded in an optically isotropic polymer. The anisotropy of the diffusion of the light in this system therefore depends only on the anisotropic scattering from a single nematic droplet and on the average orientation of the droplets in PDLCs. We calculated the expected anisotropy of the diffusion constant of light as a function of the external field, the radius of the droplets, the volume fraction of the nematic droplets and the configuration of the droplets using the theory of van Tiggelen and Stark (B. van Tiggelen and H. Stark, *Rev. Mod. Phys.* **72**, 1017 (2000)). The discrete dipole approximation was used to calculate the scattering cross-section of a single nematic droplet. Our results showed that the sign and the size of the anisotropy in the PDLC system is not a trivial function of the relevant parameters, i.e., the configuration of the nematic droplets, the indices of refraction and the shape of the droplets.

Nonlinear optics

In the Nonlinear Optics Laboratory we study new materials and their interaction with laser light. We are especially interested in new materials that promise new applications in the following highly competitive fields: optical data storage, optical processing and telecommunications, especially in the form of integrated optics. We are also interested in compact laser sources in the eye-safe wavelength region of 1550 nm. We cooperated with Fotona from Ljubljana and with the National Institute for Materials Science in Tsukuba, Japan, studying the optical properties of domain-engineered LiTaO_3 crystals with Mg doping and various degrees of stoichiometry. In addition, we studied nonlinear conversion in KTP (Potassium Titanyl Phosphate) monolithic crystals. All these crystals are suited for the optical parametric conversion from the Nd:YAG wavelength to the eye-safe region and we can obtain more than 8 mJ energy per pulse. This is the maximum energy for eye-safe operation.

Biomedical optics

We have investigated the potential of pulsed photo-thermal radiometry (PPTR) for the non-contact characterization of vascular lesions in human skin. We have developed an original numerical algorithm for the reconstruction of axial temperature profiles from measured radiometric transients. Using this algorithm, which includes automated adaptive regularization, we have performed numerical simulations of the procedure to determine the influence of experimental parameters (e.g., the selection of an IR detector, the acquisition of the spectral band, and the value of the effective absorption coefficient) on the results.

The PPTR system's performance was tested by systematic measurements in dedicated tissue models and the correlation of the results with optical coherence tomography and histology. We applied this technique to study the effect of a prototype dual-wavelength laser system on port-wine-stain (PWS) birthmarks in patient volunteers (In collaboration with Beckman Laser Institute, University of California at Irvine).

In collaboration with Clinical Center Ljubljana (Department for Plastic Surgery and Burns) and Fotona d.d., Ljubljana, we have continued with clinical trials of dermatological laser therapy, primarily involving PWS and keloid scars, but also involving a prototype dual-wavelength laser system fitted with a cryogen cooling device. These studies involve objective measurements of skin colour with a tri-stimulus colorimeter, supported with custom software governing acquisition, archiving, and analysis of the results.

In a numerical study and animal model experiments we have demonstrated the potential of a novel therapeutic protocol (repetitive dual-wavelength irradiation with intermittent cryogen cooling) for the treatment of dermatologic vascular deformations (in a collaboration with the Beckman Laser Institute, UC Irvine).

Biological systems

We continued our research on biological samples and expanded them to biomimetic systems. Using magneto-optical tweezers we performed preliminary microrheological experiments on cytoskeletal proteins and determined the parameters of the cross-linked networks. Biomimetic directed motion was successfully generated in thin samples of isotropic liquids. Combining nanolithographic methods and magnetic tweezers we created a surface with attached superparamagnetic-bead chains, which is a very good model for studying hydrodynamics in the vicinity of cell flagella.

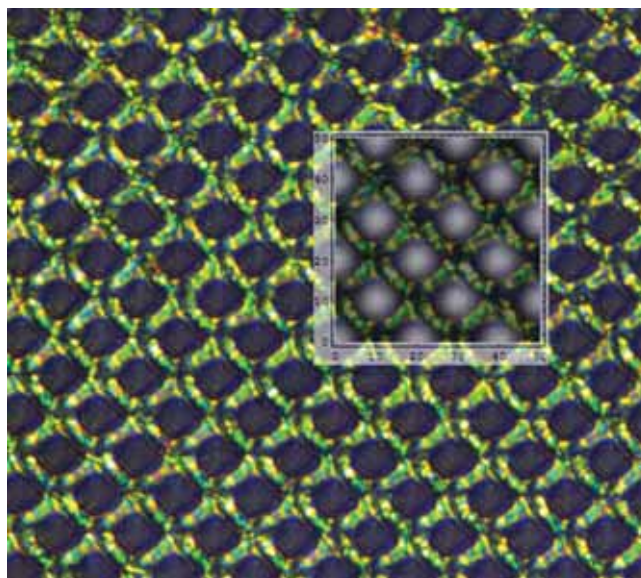


Figure 2: Optical microscope image of a two-dimensional holographically formed polymer-dispersed liquid crystal grating with added simulated intensity profile of recording laser interference (inset size 50x50 microns) (foto: M.Devetak).

Some outstanding publications in 2007

1. M. Ploscaru, S. Jenko, M. Uplaznik, D. Vengust, D. Turk, A. Mrzel, D. Mihailović, $\text{Mo}_6\text{S}_9\text{I}_x$ nanowire recognitive molecular-scale connectivity. *Nano lett.*, vol.7, no. 6 (2007), 1445–1448. [COBISS.SI-ID 20810279]
2. M. Avsec, I. Drevenšek Olenik, A. Mertelj, S. P. Gorkhali, G.P. Crawford, M. Čopič, Band structure of orientational modes in quasiperiodic mesoscale liquid-crystal-polymer dispersion, *Phys. Rev. Lett.* Vol. 98, No. 17 (2007), 173901-1–173901-4. [COBISS.SI-ID 20725799]
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4. M. Milanič, B. Majaron, J. S. Nelson, Pulsed photothermal temperature profiling of agar tissue phantoms, *Lasers med. sci.* vol. 22 (2007), 279–284. [COBISS.SI-ID 20953383]
5. R. Yusupov, V. Kabanov, D. Mihailović, K. Conder, K.A. Müller, H. Keller, Spontaneous ferromagnetic spin ordering at the surface of La_2CuO_4 , *Phys. rev., B, Condens. matter mater. phys.* (2007), vol. 76, no. 2, 024428-1–024428-9. [COBISS.SI-ID 20902439]
6. K. Kunstelj, F. Federiconi, L. Spindler, I. Drevenšek Olenik, Self-organization of guanosine 5'-monophosphate on mica, *Colloids surf., B Biointerfaces*, vol. 59 (2007), 120–127. [COBISS.SI-ID 20947495]
7. T. Mertelj, V. Kabanov, J.G. Miranda Mena, D. Mihailović, Self-organization of charged particles on a two-dimensional lattice to anisotropic Jahn-Teller-type interaction and three-dimensional Coulomb repulsion, *Phys. rev., B, Condens. matter mater. phys.* (2007), vol. 76, no. 5, 054523-1–054523-9. [COBISS.SI-ID 20990247]

Patent granted

1. Alessandro Lukan
Instrument for flow measurement of fluids with more ranges: Patent No. 22314
Ljubljana, Urad RS za intelektualno lastnino, 2007

Awards and appointments

1. Viktor V. Kabanov: Zois award (Republic of Slovenia) for outstanding achievements in science in the field of condensed matter physics

Organization of conferences, congresses and meetings

1. SLONANO 2007: Symposium on the science and technology of nanomaterials in Slovenia. Co-organiser, 10.10.–12.10.2007

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Ph. D. Thesis

- Primož Kušar: Influence of irregularities and dimensionality on electron relaxation (Dragan Mihailović)

B. Sc. Theses

- Anton Gradišek: Časovna odvisnost magnetooptične kerrove rotacije v fotovzbujenih tankih filmih (Pr, Ca)MnO₃ (Tomaž Mertelj)
- Mitja Knez: Izdelava sistema za kolorimetrične meritve v dermatologiji (Boris Majaron)

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- Electronic Response of Molybdenum-based Nanowires
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Prof. Dragan Mihailović
- Controlling Mesoscopic Phase Separation
COMEPHS, 6. FP
NMP4-CT-2005-517039
EC, Prof. E. Liarokapis, National Technical University of Athens, Zografou, Athens, Greece
Prof. Dragan Mihailović
- Design, Synthesis and Growth of Nanotubes for Industrial Technology
DESYGN-IT, 6. FP
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Grace Dempsey, The Provost Fellows and Scholars of the College of the Holy and Undivided Trinity of Queen Elizabeth near Dublin, Dublin, Ireland
Prof. Dragan Mihailović
- Ultrafast Processes in Low-Dimensional Nanomaterials
NATO Reintegration Grant
PDD (CD)-(EAP.RIG 981425)
Dr. F. Pedrazzini, NATO, Public Diplomacy Division, Collaborative Programmes Section, Brussels, Belgium
Asst. Prof. Jure Demšar
- Processes in Biophysical Matter Studied with Optical Tweezers
NATO Reintegration Grant
PDD (CD)-(EAP.RIG 981424)
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- Photonic Structures from Polymer-Liquid Crystal Composites
BI-AT/07-08-004
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- Guanosine-based Nanodevices on Polymeric Templates
PROTEUS
BI-FR07-PROTEUS-015
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- Surface Structure of Guanosine Derivatives on Solid Substrates
BI-IT/05-08-008
Prof. Paolo Mariani, Facoltà di Scienze, Università Politecnica delle Marche, Ancona, Italy
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- Fabrication and Characterization of New Ultraviolet Nonlinear Optic Materials
BI-CN/07-09-024
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R & D GRANTS AND CONTRACTS

- Polymeric nanocomposites
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- Development of novel laser therapies for dermatologic vascular lesion
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- Biophysical processes studied with optical tweezers
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- Biodosimetry by magnetic resonance methods
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RESEARCH PROGRAMS

- Theoretical physics of nuclei, particles and fields
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VISITORS FROM ABROAD

- Scott Woltman, Department of Physics, Brown University, USA, 20 February – 06 March 2007.
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- Primož Kušar, B. Sc.
- Matija Milanič, B. Sc.
- Andrej Petelin, B. Sc.
- Jure Strle, B. Sc.
- Andrej Tomelj, B. Sc.
- Marko Uplaznik, B. Sc.
- Mathieu Lu dac, B. Sc.

Technical officers

- Boštjan Berčič, B. Sc.
- Martina Knavs, B. Sc.
- Alessandro Lukan, B. Sc.
- Tamara Matevc, B. Sc.
- Damjan Vengust, B. Sc.

Technical and administrative staff

- Marko Koren

Ph.D. Students from Abroad

- Mihaela Ploscaru, B. Sc., Romania
- Joaquin Gabriel Miranda Mena, M.Sc., Mexico

* Full-time faculty member

** Part-time faculty member

*** Member of industrial or other organisation

DEPARTMENT OF REACTOR PHYSICS

F-8

During the past year we have been working primarily on:

- *theoretical, experimental and applied reactor physics*
- *plasma physics*
- *neutron transport calculations*
- *semiconductor physics*
- *medical physics*

Our research in **reactor physics** has focused mainly on new methods for power and research reactor calculations, where special attention has been given to the calibration and benchmarking of nuclear data and to computational methods. We have linked theoretical and practical reactor physics by participating in a project to evaluate older, critical safety experiments, which is hosted by the Idaho National Laboratory. With the use of advanced Monte Carlo techniques, we evaluated the criticality and uncertainties of an exotic experimental reactor, in which fuel in the form of a plutonium-uranyl nitrate solution was used. We have focused attention on Monte Carlo neutron, photon and electron transport and nuclear data processing for transport calculations, and on advanced nodal methods aimed at detailed power-distribution reconstruction. The results of this basic research have been published in a number of papers, both in scientific journals and in conference proceedings. We continued with the implementation and verification of our new, two-dimensional program package for the TRIGA research reactor burn-up calculations. We have completed the work on an expert opinion connected with the introduction of the 'BEACON' core-monitoring system. We have entered the field of new neutron sources in collaboration with the Institute for Transuranium Elements, where we study neutron production in an ultra-fast pulsed-laser interaction with matter. This year we initiated, in collaboration with the Department for Nanostructured Materials, the development and irradiation of SiC-fibre based on low-activation composite materials for the first wall of a future fusion reactor. The activation of the candidate materials was experimentally determined by irradiation in a reactor neutron beam, followed by gamma spectroscopy. For a better interpretation of the results a calculation of the differences between the activation characteristics in a fission and a fusion neutron beam was performed.

In the field of **plasma physics** we have continued our studies of the potential formation in front of negative and positive electrodes immersed in a plasma. The fluid model of the current-voltage characteristics of an electron-emitting electrode immersed in a two-electron temperature plasma has now been developed to a relatively advanced level. Using this model we have presented the first detailed quantitative explanation of a triple floating potential that has been observed on the current-voltage characteristics of an electron-emitting electrode immersed in a plasma where a high-energy electron population is present. We have performed a detailed analysis of the transitions between the space-charge-limited and temperature-limited electron emission from the electrode. In parallel, an analogous kinetic model has been developed for a bounded plasma system. Axial profiles of the potential, the electric field and the space-charge density have been calculated using numerical solutions of the Poisson equation. Very good agreement with the PIC computer simulations was found. Studies of the potential formation in the presence of two species of positive ions in the plasma and in the presence of an oblique magnetic field have also been initiated. We have studied the nonlinear dynamics of the potential oscillations in front of a positive electrode immersed in a plasma. Detailed experimental investigations performed some time ago have now been complemented with PIC computer simulations. In this way more detailed measurements of the plasma parameters during various phases of the electron saturation current oscillations were possible. When the electrode bias was modulated by an external harmonic voltage, synchronization and periodic pulling were



Head:
Prof. Bogdan Glumac

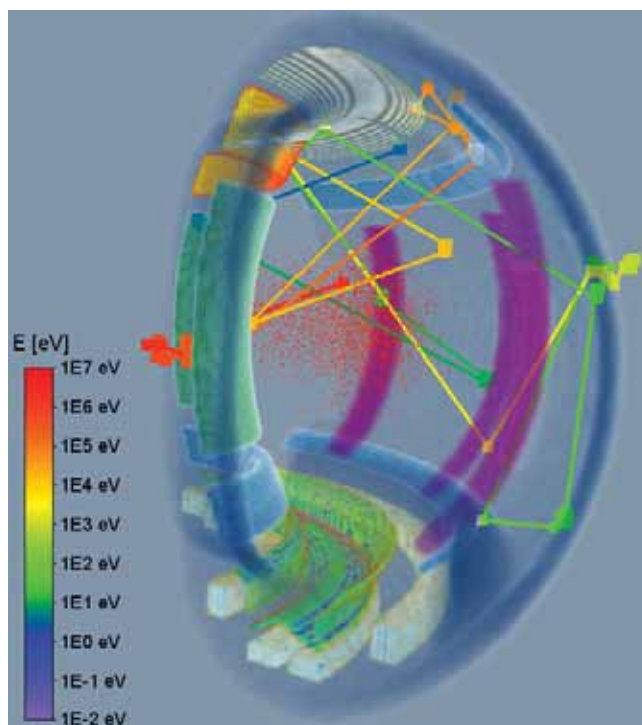


Figure 1: Track of a particular neutron inside the JET torus – the scattering positions are marked with a colour representing the corresponding neutron energy. The main structures of one quarter of the torus are represented in a semi-transparent manner; red dots represent the plasma distribution.

observed. These two characteristic nonlinear phenomena can be modelled using a model of the van der Pol oscillator. At the end of this year, the three-year contract between EURATOM and the Ministry for Higher Education, Science and Technology, by which the Slovenian Fusion Association was established, expired. A sizeable amount of time was therefore spent this year in the Research Unit of the association to organize and coordinate the work plan for the mid-term period of the next three years. The plan is a part of the new contract of association, which was signed by the minister Mojca Kucler Dolinar in December. It will expire in December 2013. In parallel with preparing the work plan it was necessary to elaborate the research work programme for 2008. The research work will be performed within 13 projects, in which the researchers from 5 research departments of the Jožef Stefan Institute are involved. Researchers from the Faculty for Electrical Engineering of the University of Ljubljana and from the University of Nova Gorica collaborate as well. As it was before, all the research work will be performed in close collaboration with partners from all over the Europe and coordinated by the EFDA. We are also taking care to popularise fusion-energy development, and at the Nuclear Training Centre a permanent exhibition on fusion energy is open and several lectures on the importance of fusion-energy development are offered to visitors.

The collaboration with JET (Joint European Torus), the largest fusion reactor in the world, was intensified, especially in the field of **neutron transport calculations**. Co-workers of the reactor physics division collaborated on the beryllium-wall upgrade project and predicted future changes in the neutron and g field during longer visits to the institute, which is situated in the UK. The response of the neutron detectors was modelled with the Monte Carlo method and the sensitivity of the response with regards to the changes of some components in the torus was estimated. It was found that the diagnostics is relatively insensitive to changes in the configuration of the torus. Another topic was the modelling of an irradiation probe's response and experimental results were successfully interpreted using transport calculations. Besides this, the differential distribution of the γ rays was calculated and their influence on the profile monitor's response was assessed. In the frame of the Gamma-Ray Camera's Upgrade Project the neutron attenuation in the planned shields for the γ cameras and the neutron field around the cameras were calculated. Activation of the SiC/SiC composite, a material developed for the first wall of future fusion reactors by the Department for Nanostructured Materials, was calculated. The activation is dependent mainly on impurities, needed for the sintering process. Neutron transport and activation calculations were coupled and the results show that in the case of a deuterium-deuterium plasma the activation in the first wall is dominated by thermal neutrons and irradiations in the TRIGA reactor fairly closely resemble the conditions in a fusion reactor. In the case of a deuterium-tritium plasma, the conditions change and a prediction of the activation becomes difficult for irradiations in fission reactors. It has also been established that the activation of a compound is the sum of the activations of individually irradiated elements.

Within the area of **semiconductor devices** the investigations were carried out within the framework of the bilateral Slovenian-Ukraine scientific cooperation. The initial phase of the joint research program with the Chernivtsi National University, Chernivtsi, Ukraine in spintronics is focused on the high-temperature ferromagnetic p-doped ZnO thin layer that is considered to be a likely candidate, eventually allowing the spin-polarized current within it to be manipulated in a controlled way. The ZnO:Co thin films were grown by radio-frequency magnetron sputtering at 300 K for given values of the Co dopant concentration and their optical (the transmission, reflection and photoluminescence) properties were measured and analyzed for different film-deposition conditions with regard to the appropriate choice of the carrier gas (argon, air) and a suitable substrate (sapphire, silicon and sital). The effect of the spontaneous aging of the organic semiconductor devices is an important open question. In this respect it was shown that the capacitance-voltage data of the ionized cluster beam deposited bilayer ITO/CuPc/PTCDA/Al, p - P isotype organic structure, taken immediately after its formation and after one year of exposure to a room's ambient conditions, exhibits a strong 8.8 V upshift of the transition voltage. With a detailed analysis of the C-U line characteristics it was determined that the transition voltage upshift is related to a substantial increase in the trap density, as occurs within the aged organic structure. It is thought that the trap-density augmentation primarily occurs on account of the humid-air water molecules diffusing into the organic structure where they subsequently dissociate into the hole traps.

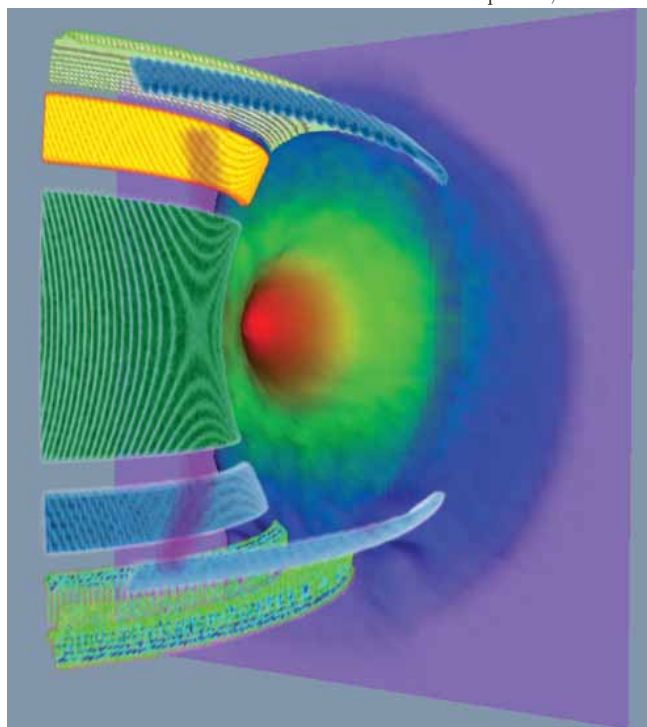


Figure 2: Neutron flux distribution inside the JET torus - the flux intensity is represented with the corresponding colour and height of field. The main structures of one quarter of the torus are presented in a semi-transparent manner.

Our research in the field of **medical physics** has been focused on three main areas: cancer-treatment assessment with biomedical imaging, radiobiological studies on zebrafish, and computer simulations of cancer growth and the response to therapy. In cancer-treatment assessment we are using biomedical imaging, particularly positron emission tomography (PET) using novel tracers of cellular proliferation (FLT) and hypoxia (CuATSM) to assess the biological substructure of tumours prior to and during anti-neoplastic therapies. We are performing experiments on small animals (mice) and large animals (dogs with spontaneous tumours). In addition, we are involved in several human clinical trials in patients with brain, head and neck, lung, esophagus, and prostate tumours as well as patients with leukemia and lymphomas. In the previous year we have completed a preclinical study on dogs with lymphomas, investigating the treatment efficacy of a novel drug, which provided the basis for an accelerated start of a human clinical trial. In patients receiving radiotherapy, chemoradiotherapy and molecular targeted therapies we have observed large heterogeneity and variability of pre-treatment biological substructures as well as complex dynamics of the response. For radiobiological studies on zebrafish we have developed a new image-guided micro-irradiator, which is capable of the localized irradiation of zebrafish embryos with photon fields of less than 1 mm in diameter. This will enable radiobiological studies of localized irradiation, similar to the conditions met in external beam radiotherapy. In preliminary studies, comparing total and partial body irradiation, following up apoptosis and inflammatory response, we observed that while apoptosis is high in both cases, inflammatory response is significant only during partial irradiation. In computer simulations of cancer growth and the response to therapy we have developed a stochastic multi-layer model which feeds from biomedical images. In parallel we have developed a vasculature growth model. We have been able to apply the models to experimental datasets of in-vitro and in-vivo experiments. This provides a foundation for the future development of a biological cancer-treatment plan.

Some outstanding publications in 2007

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2. T. Zhang, W. Lu, G.H. Olivera, H. Keller, Robert Jeraj, R. Manon, M. Mehta, T.R. Mackie, B. Paliwal, Breathing-synchronized delivery : a potential four-dimensional tomotherapy treatment technique. *Int. j. radiat. oncol. biol. phys.*. [Print ed.], 2007, vol. 68, str. 1572–1578.
3. M. Rodriguez, S. Griffin, L. Dewerd, Robert Jeraj. Characterization of the ADII-33 diamond detector. *Med. phys. (Lanc.)*, 2007, issue 1, vol. 34, str. 215–220.
4. M.W. Kissick, T.R. Mackie, Robert Jeraj. A delivery transfer function (DTF) analysis for helical tomotherapy. *Phys. Med. Biol.*, 2007, issue 9, vol. 52, str. 2355–2365.
5. M.W. McCall, Robert Jeraj. Dual-component model of respiratory motion based on the periodic autoregressive moving average (peridoc ARMA) method. *Phys. Med. Biol.*, 2007, issue 12, vol. 52, str. 3455–3466.
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4. Matjaž Ravnik, Luka Snoj
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5. Matjaž Ravnik, Luka Snoj
Kritični eksperiment in odziv na spremembe reaktivnosti: navodila za vajo
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6. Matjaž Ravnik, Luka Snoj
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7. Matjaž Ravnik, Luka Snoj
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8. Matjaž Ravnik, Luka Snoj
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Ljubljana, samozaložba, 2007.

THESES

M. Sc. Thesis

1. Bojan Žagar, Potential formation in front of a floating electrode in a magnetized bounded plasma system (Tomaž Gyergyek)

B. Sc. Theses

1. Jernej Kovačič, Potential formation in a plasma diode containing hot and emitted electrons (Tomaž Gyergyek)
2. Martin Krššák, Nonlinear dynamics of potential relaxation oscillations in a bounded plasma system (comentor Tomaž Gyergyek)
3. Rok Rudolf, Calculation of transuranic actinides in nuclear power plant spent fuel (Matjaž Ravnik)
4. Gašper Žerovnik, Characterization of neutron field in irradiation channels of TRIGA reactor (Matjaž Ravnik)

INTERNATIONAL PROJECTS

1. Nuclear Data: Benchmark Experiments to validate EFF/EAF Data (TW6-TTMN-002B) - T1.002B-FU
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
FU07-CT-2007-00016 (EFDA 07-1708)
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Andrej Trkov
2. Nuclear Data: EFF/EAF Data File Upgrade, Processing and Benchmark Analyses (TW6-TTMN 001B) - T1.001B-FU
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
FU07-CT-2007-00016 (EFDA 07-1708)
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Andrej Trkov
3. Update of the JET MCNP Model - J2-FU
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Igor Lengar
4. Upgrade of Gamma-Ray Cameras: Neutron Attenuators (GRC) - J1/b
EFDA Task Agreement Code: JW6-TA-EP2-GRC-01, Contract No.: JW6-NEP-MHST-01
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Igor Lengar
5. Upgrade of Gamma-Ray Cameras: Neutron Attenuators (GRC) - J1/a (JET)
EFDA Task Agreement Code: JW6-TA-EP2-GRC-01, Contract No.: JW6-OEP-MHST-01
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Igor Lengar
6. Research Unit - Administration and Services - RU-FU
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Prof. Milan Čerček, Asst. Prof. Saša Novak Krmpotič
7. Nuclear Data: Benchmark Experiments to Validate EFF/EAF Data (TW7-TTMN-002) - T1-FU
EURATOM - MHST, 7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Dr. Andrej Trkov
8. Collaboration in DEMO Working Group - P7-FU
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083

- EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Prof. Matjaž Ravnik
9. Interaction of Vibrationally Excited Hydrogen with Fusion Relevant Materials - P2-FU
EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Prof. Milan Čerček, Dr. Iztok Čadež
 10. Transport Processes of Light and Heavy Ions in Matter and their Application in Medicine, Intercontinental and Space Flights and Nuclear Waste
BI-RU/05-07-011
Alexander Golovchenko, Joint Institute for Nuclear Research, Dubna, Moscow Region, Russia
Dr. Marko Giacomelli

R & D GRANTS AND CONTRACTS

1. High energy ion interactions in tissue-like materials and metals
Dr. Igor Lengar
2. Investigation of fusion relevant phenomena in plasma-wall interaction
Prof. Milan Čerček
3. Radiation field characterization for diagnostic and therapeutic use of radioactive isotopes
Asst. Prof. Robert Jeraj
4. On the use of benchmark experiment for improved utilisation of nuclear facilities
Asst. Prof. Andrej Trkov
5. Prevention and reduction of the consequences of the terrorist attack on TRIGA research reactor
Prof. Matjaž Ravnik
6. Interfacial amorphization and Fermi level pinning
Prof. Igor Jenčič, Prof. Bruno Cvikl
7. Development of the diagnostics for certain parameters of the edge plasma in fusion devices
Prof. Milan Čerček
8. Fusion relevant research of plasma interaction with surfaces
Prof. Milan Čerček
9. PET with a novel photon detector
Prof. Peter Kržan
10. A development of low-activation material for the first wall in fusion reactor.
Asst. Prof. Saša Novak Krmpotič

RESEARCH PROGRAM

1. Reactor Physics
Prof. Bogdan Glumac

NEW CONTRACT

1. Calculation of isotopic composition and decay heat for Krsko NPP spent fuel
ARAO
Prof. dr. Matjaž Ravnik

VISITORS FROM ABROAD

1. mag. Alexander Golovchenko, Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research, Dubna, Russia, 22. 6. - 14. 9. 2007

2. prof. Petro Gorley and dr. Sergii Bilichuk, University Chernivci, Ukraine, 11. 9. 2007
3. prof. Roman Schrittwieser and dr. Codrina Ionita - Schrittwieser, Institute for Ion Physics, University of Innsbruck, Innsbruck, Austria, 3. 12. - 16. 12. 2007

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DEPARTMENT OF EXPERIMENTAL PARTICLE PHYSICS

F-9

The department's research is devoted to experimental studies of elementary particles, to revealing the ultimate building blocks of matter and the nature of the interactions between them. The experiments are carried out within large collaborative programmes at international centres for particle physics, at CERN near Geneva, at DESY in Hamburg and at KEK in Tsukuba. The department is also engaged in developing and applying technologically advanced particle detectors, which are demanded by such measurements. Astroparticle physics is an emerging field, applying the experimental techniques of particle physics to solving astrophysical problems. Slovenian researchers are participating in the construction of the Pierre Auger observatory and in the first measurements of ultra-high-energy cosmic rays, with the apparatus spread over 3000 km² near Malargue in Argentina.



Head:
Prof. Marko Mikuž

In order to reveal the ultimate secrets of nature in the world of elementary particles, accelerators with higher and higher energies are needed. Their cost, both in terms of money and human resources, has grown to the level where they are affordable only as joint international enterprises. Thus, future accelerators will be unique facilities of their kind, the first being the Large Hadron Collider (LHC), being completed at the European Organization for Nuclear Research (CERN) near Geneva. Researchers will exploit this facility to perform experiments in presently inaccessible regions of energy, which, though pushed higher and higher, still remain minute compared to that of the vast blast of the Big Bang that led to the creation of the Universe.

Together with colleagues from the Physics Department of the Faculty of Mathematics and Physics and the Faculty of Electrical Engineering of the University of Ljubljana, and from the Faculty of Chemistry and Chemical Technology of the University of Maribor, we are performing measurements at CERN, the German centre DESY in Hamburg and the Japanese centre KEK in Tsukuba. We are taking part in three experiments, each conducted as an international collaboration:

- ATLAS at the Large Hadron Collider (LHC) at CERN (2000 researchers, 167 institutions),
- Belle at the asymmetric electron-positron collider (KEK-B) at KEK (380 researchers, 55 institutions),
- HERA-B at the HERA electron-proton collider at DESY (310 researchers, 33 institutions).

In the field of astroparticle physics we are part of the Pierre Auger collaboration (200 researchers, 55 institutions), which uses a giant scale (3000 km²) observatory near Malargue in Argentina for the detection of ultra-high-energy cosmic rays. This endeavour is carried out in collaboration with colleagues from the University of Nova Gorica.

A detailed report on the activities of 2007 follows, focused on the contributions of our researchers:

ATLAS:

- Throughout the whole year the intensive installation of huge detector parts was taking place in the experimental cavern 160 m underground, followed by their connection to services and commissioning with cosmic rays. By the end of 2007, most of the detector was ready to take data.
- While testing the cooling of the SemiConductor Tracker, a serious incident occurred, blowing up one of the exhaust heaters. Substantial modifications to the system were required, delaying commissioning of the SCT. Thus only the barrel part could be commissioned with cosmic rays, while for the end-caps, successfully installed in 2007, the commissioning is on-going.
- In January we successfully installed all eight detector modules with diamond sensors for the Beam Conditions Monitor (Fig. 1). Test beam data with spare modules enabled refinements to the read out. The data acquisition, based on FPGAs, has been developed with the aim to deliver feed back, inclusive of an abort signal, to the LHC machine.

Researchers at the Pierre Auger Cosmic Ray Observatory published an article in Science, pointing out the observed correlation between the arrival directions of ultra-high-energy cosmic rays and active galactic nuclei.



Figure 1: Four detector modules of the ATLAS Beam Conditions Monitor installed in the support structure of the pixel detector. The 72-mm-diameter beam pipe can be seen, as well as the pixel detector in the background.

- Online integrating radiation monitors were produced and installed in ATLAS. Fourteen monitors with a wide dynamic range and a thermal neutron detection capability were placed in the Inner Detector, while 50 simpler monitors, measuring TID and NIEL damage only, were spread throughout the ATLAS detector.
- We have continued our studies of the radiation hardness of silicon sensors and readout electronics, to extend their range to particle tracking in future colliders. Part of this activity was carried out in the framework of CERN RD-50.
- We joined the CERN RD-42 collaboration in their effort to provide position-sensitive detectors based on polycrystalline and single-crystal CVD diamonds. We submitted a proposal for an ATLAS pixel-detector upgrade utilizing pCVD diamond detectors.
- A large number of flexible heater pads with dimensions up to 1.9 x 0.4 m on copper-Kapton laminates were designed and produced for the SCT and ID thermal enclosure.
- Generation of the phase-space in proton collisions at 14 TeV was studied.
- The background to the Higgs boson searches in the Standard Model and MSSM was simulated in detail.
- We studied top-quark production in proton-proton collisions and upgraded the relevant simulation programme.
- The contribution of quantum chromodynamics phenomena to the precise determination of the top-quark mass was studied.
- The grid infrastructure on the SiNET computer cluster has been constantly upgraded and the Nordugrid(ARC) and EGEE(gLite) middleware platforms maintained. We became full members of WLCG as the Slovenian TIER-2 centre. We took part in the "ATLAS Computing System Commissioning" exercise.

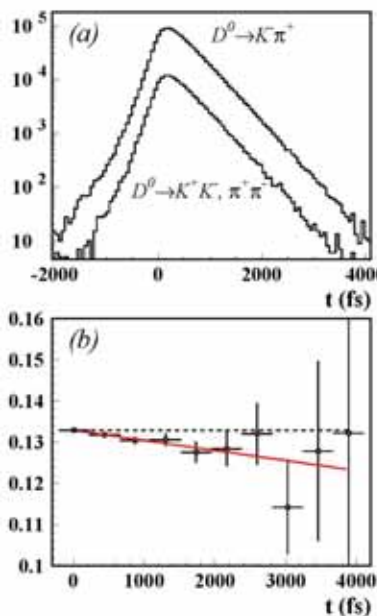


Figure 2: Decay-time distribution for the decay of neutral D mesons into pion or kaon pairs and the same distribution for the decay in pion-kaon pairs (a). The tiny difference in the shapes between the two distributions visible in their ratio (b) is a consequence of D-meson mixing.

BELLE

- For the first time we obtained experimental evidence of the mixing of D^0 mesons by measuring decays into CP eigenstates ($D^0 \rightarrow K^+ K^-, \pi^+ \pi^-,$ Fig. 2.); the expected rate of mixing in the Standard Model (SM) is small and the measured values impose constraints on the parameters of the models beyond the SM (also known as New Physics, for example, theories including supersymmetric particles);
- By measuring the decay-time dependence of the Dalitz distribution in the $D^0 \rightarrow K_S^0 \pi^+ \pi^-$ decays we determined, for the first time with a significant accuracy, the mass difference of the mass eigenstates in the neutral D meson system; this difference is one of the (inaccurately predicted) parameters of the SM;
- For the first time we measured the semileptonic B meson decays involving the tau leptons ($B^0 \rightarrow D^* \tau^+ \nu_\tau$); the measurement of the decay rate puts limits on the possible masses of particles in the extensions of the SM with several Higgs bosons;
- We continued the measurements of the CP violation in $B^+ \rightarrow K^+ \pi^0$ and $B^0 \rightarrow K^+ \pi^-$ decays; the difference between the two types of decays may represent a hint of the New Physics processes;
- We performed numerous measurements in the field of charmed hadrons spectroscopy; the most important are discoveries of new resonances in the process of $e^+ e^- \rightarrow J/\psi X$, and the determination of the quantum numbers of the $\Lambda_c(2880)$ baryon; some of the discovered states do not possess properties that would enable their positioning in the system of conventional SM particles;
- We measured several production cross-sections for the $e^+ e^- \rightarrow X_c \bar{X}_c$, where X_c represents a charmed hadron; the measurements enable tests of the predicted properties of charmonium (c anti-c) states;
- We measured the rates of several decays of B_s mesons produced from the U(5S);
- We accurately measured the rate of $B^0 \rightarrow D_s^+ D^-$ decays and put an upper limit on the rate of $B^0 \rightarrow D_s^+ D_s^-$ decays; the latter has excluded some of the related theoretical models;
- We developed a method for the determination of the D_s meson decay constant; a comparison with the predictions of the lattice QCD calculations will enable tests of the latter;
- We initiated the measurement of mixing in $D^0 \rightarrow \phi K_S^0$ decays;
- We started the measurement of the CP asymmetry in $D^0 \rightarrow K^+ K^-, \pi^+ \pi^-$ decays; an observation of significant CP violation would unambiguously indicate contributions of New Physics;
- We studied the possibilities of measurements with a new generation of "B-factories" with 10-50 times higher luminosity than currently available;
- We started preparations for the upgrade of the KEKB collider and the Belle detector to the higher luminosity; with colleagues from the US, Italy, France, Japan and the UK we published a detailed study on the possibility of building a new generation B-factory;
- We studied a new type of Cherenkov radiation detector, the TOP (time-of-propagation) detector and developed a method for data analysis;
- We continued the development of a new aerogel Cherenkov detector, tested different aerogel radiator configurations as well as the possibility of time-of-flight measurements.

HERA-B

- Results of the measurements of cross sections for the production of scalar and vector D mesons were published;
- We developed a new method for charged-particle identification based on Ring Imaging Cherenkov data and used it to measure deuteron and anti-deuteron production in proton-nucleus collisions at high energies.

PIERRE AUGER

- Fluorescence detectors at four locations were finalized and collected data all year during clear, moonless nights;
- The fourth Lidar station was put into operation, their data-acquisition system and software upgraded, enabling fully automated monitoring of atmospheric conditions.
- Installation of ground detectors was practically finished, now covering over 90% of the planned detection surface;
- A preliminary study of the energy spectrum at the GZK cut-off was performed. The results are not significant yet and further calibration of the detector is needed;
- Analysis of the arrival direction of 27 measured cosmic rays of the highest energies exhibited a correlation with active galactic nuclei (Fig. 3). These results were published in Science.

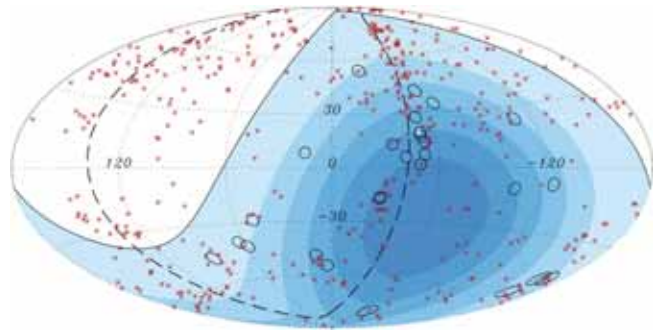


Figure 3: Correlation between the arrival directions of the 27 cosmic rays of the highest energies, measured by the Pierre Auger observatory (circles), and the positions of the 472 active galactic nuclei (red asterisks). The field of view of the observatory is shown in blue, deeper colours indicate longer exposure. The plot is drawn in galactic coordinates.

Detector development

- In collaboration with CERN, University of Valencia, University of Michigan, Ann Arbor and Ohio State University work on the Compton camera and a novel PET apparatus, based on position-sensitive silicon detectors, has been continued;
- A prototype detector for a brachytherapy source locator was assembled;
- An aerogel Cherenkov detector for ^{90}Sr in environmental samples was built.

Organization of conferences, congresses and meetings

1. FPCP 2007 Flavor Physics and CP Violation, Bled, Slovenia, 12. 5. 2007 – 16. 5. 2007

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THESES

Ph. D. Theses

1. Urban Bitenc: Measurement of D^0 mixing using semileptonic decays (Supervisor: Prof. Boštjan Golob)
2. Saša Fratina: Measurement of time dependent CP violation in $B^0 \rightarrow D^+$ and D decays (Supervisor: Asst. Prof. Samo Korpar)
3. Samo Kupper: Charm production in 920 GeV proton-nucleus interactions (Supervisor: Prof. Marko Starič)

B. Sc. Theses

1. Rok Dolenc: Detection of single photons with a silicon photomultiplier (Supervisor: Asst. Prof. Samo Korpar)
2. Janez Langus: Measurements of signals in 3D silicon detectors (Supervisors: Prof. Vladimir Cindro, Dr. Gregor Kramberger)
3. Peter Smerkol: Search for $B^+ \rightarrow \chi_{c2} K^+$ decays with the Belle detector (Supervisor: Prof. Boštjan Golob)
4. Andrej Petelin: Identification of hadrons with a RICH counter in the Belle spectrometer (Supervisor: Prof. Peter Križan)
5. Jožef Pulko: Measurements of radiation damage in silicon detectors (Supervisor: Prof. Vladimir Cindro)

INTERNATIONAL PROJECTS

1. Enabling Grids for E-science-II
EGEE-II
EGEE-NA1, EGEE-NA2, EGEE-NA3, EGEE-NA4
6. FP; 031688
EC; Dr. Bob Jones, CERN IT-EGE, Geneve, Switzerland
Prof. Marko Mikuž
2. Safe Production and Use of Nanomaterials
NANOSAFE2
6. FP; NMP2-CT-2005-515843
EC; Commissariat a l'Energie Atomique, Grenoble, France
Andrej Detela, B. Sc., Asst. Prof. Maja Remškar, Marko Žumer, B. Sc., Prof. Boris Turk
3. The Charge Collection Study in Microstrip Silicon Detectors for Quality Assurance CERN ATLAS SCT Program and the Future Upgrade for LHC Experiments
INTAS 03-52-5744
INTAS - International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union, Brussels, Belgium; Dr. Jaakko Härkönen, Helsinki Institute of Physics, CSM Programme, CERN/EP, Geneve; CERN Office, CERN/PH, Geneve, Switzerland
Prof. Marko Mikuž
4. Collaboration DELPHI
Dr. Jan Timmermans, CERN, Geneve, Switzerland
Asst. Prof. Borut Paul Kerševan
5. Collaboration HERA-B
Dr. Mike Medinnis, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany
Prof. Peter Križan
6. Collaboration ATLAS
Prof. Peter Jenni, CERN, Geneve, Switzerland
Prof. Marko Mikuž
7. Collaboration CERN RD-39
Dr. Jaako Haarkonen, HIP, Finland
Dr. Zheng Li, BNL, USA
Prof. Marko Mikuž
8. Collaboration CERN RD-42
Prof. Peter Weilhammer, CERN, Geneve, Switzerland
Prof. Marko Mikuž
9. Collaboration CERN RD-50
Prof. Mara Bruzzi, University of Florence, Florence, Italy Dr. Michael Moll, CERN, Geneve, Switzerland
Prof. Marko Mikuž
10. Collaboration Belle
Prof. Masanori Yamauchi, KEK, Tsukuba, Japan
Prof. Peter Križan
11. Collaboration CIMA
Cameras for Imaging in Medical Applications
Prof. Peter Weilhammer, CERN, Geneve, Switzerland
Prof. Marko Mikuž
12. Study of Top Events produced at the LHC for the Commissioning of the ATLAS Detector
BI-IT/05-08-003
Dr. Marina Cobal, Università di Udine, Udine, Italy
Asst. Prof. Borut Paul Kerševan

13. Measurement of Properties of Charmed Hadrons
SLO-JPN, BI-JP/07-09/C-002
Prof. Fumihiko Takasaki, High Energy Accelerator Research Organization, Tsukuba shi, Ibaraki ken, Japan
Asst. Prof. Tomi Živko

R & D GRANTS AND CONTRACTS

1. Search for exotic hadronic bound states
Asst. Prof. Tomi Živko
2. Combined method for particle identification
Asst. Prof. Samo Korpar
3. Development of high-resolution PET probe
Dr. Dejan Zontar
4. Development and Implementation of Tools for the Physics Research with the ATLAS Detector in the Grid Environment
Asst. Prof. Borut Paul Kerševan
5. Semiconductor detectors for medical and high radiation fields applications
Dr. Dejan Zontar
6. New electric direct drive systems
Andrej Detela, B. Sc.
7. Verification of radioactive sources positioning during brachytherapy
Dr. Gregor Kramberger
8. Optimization of direct drive system for electric two-wheel vehicles
Andrej Detela, B. Sc.
9. Fast detection of the radioactive Strontium-90
Asst. Prof. Samo Korpar
10. Hadron collider physics
Dr. Ilija Bizjak
11. Measurements of rare decays of B and D mesons
Asst. Prof. Samo Korpar
12. Data Analysis Tools and Environment for Physics Research with the ATLAS Detector
Asst. Prof. Borut Paul Kerševan
13. Slovene Terminology Web Portal
Jan Jona Javoršek
14. PET with a novel photon detector
Prof. Peter Križan

RESEARCH PROGRAMS

1. Astroparticle Physics
Asst. Prof. Marko Zavrtnik
2. Eksperimental Particle Physics
Prof. Marko Mikuž

NEW CONTRACT

1. Verification of radioactive sources positioning during brachytherapy
Elgo - line d.o.o.
Dr. Gregor Kramberger

VISITORS FROM ABROAD

1. Themis Bowcock, Mark Tobin, University of Liverpool, Liverpool, Great Britain, 11. 6. – 13. 6. 2007
2. Prof. Dr. Thomas Browder, University of Hawaii, Honolulu, USA, 16. 5. – 18. 5. 2007
3. Dr. Hassan Chagani, University of Sheffield, Sheffield, Great Britain, 29. 8. – 1. 9. 2007
4. Dr. Oleksiy Lytovchenko, Dr. Vladimir Khomenkov, INFN, Padova, Italy, 17. 12. – 21. 12. 2007
5. Roberto Mussa, INFN, Torino, Italy, 22. 5. 2007

6. Prof. Dr. Stephen L. Olsen, University of Hawaii, Honolulu, USA, 30.6. – 4. 7. 2007
7. Prof. Dr. Masanori Yamauchi, High Energy Accelerator Research Organization (KEK), Tsukuba, Japan, 26. 8. – 27. 8. 2007
8. Prof. Dr. Walter Schmidt-Parzefall, Institut für Experimentalphysik, Universität, Hamburg, Germany, 13. 9. – 15. 9. 2007
9. Prof. Dr. Volker Soergel, Physikalisches Institut, Ruprecht-Karis-Universität, Heidelberg, Germany
10. Dr. Georg Steinbrueck, Julian Becker, University of Hamburg, Hamburg, Germany, 11. 10. – 12. 10. 2007

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1. Prof. Vladimir Cindro**
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3. Prof. Boštjan Golob*
4. Dr. Andrej Gorišek
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6. Asst. Prof. Samo Korpar*
7. Dr. Gregor Kramberger**
8. Prof. Peter Križan*
9. Asst. Prof. Igor Mandič**
- 10. Prof. Marko Mikuž*, Head**
11. Asst. Prof. Tomaž Podobnik*
12. Prof. Aleš Stanovnik*
13. Prof. Marko Starič**
14. Prof. Danilo Zavrtanik*
15. Asst. Prof. Marko Zavrtanik**
16. Asst. Prof. Tomi Živko
17. Dr. Dejan Žontar***

Postdoctoral associates

18. Dr. Ilija Bizjak
19. Dr. Marko Bračko*
20. Dr. Matej Horvat, left 15. 5. 2007
21. Dr. Rok Pestotnik**

22. Dr. Andrej Studen**

23. Dr. Matevž Tadel

Postgraduates

24. Matej Batič**, B. Sc.
25. Dr. Urban Bitenc**
26. Irena Dolenc, B. Sc.
27. Rok Dolenc, B. Sc.
28. Dr. Saša Fratina**, B. Sc., left 1. 8. 2007
29. Boštjan Maček, B. Sc.
30. Peter Smerkol, B. Sc.
31. Anže Zupanc**, B. Sc.

Technical officers

32. Andrej Detela, B. Sc.
33. Jan Jona Javoršek, B. Sc.

Technical and administrative staff

34. Andreja Butina
35. Jure Eržen
36. Tadej Gabrič
37. Majda Kelbelj, retired 1. 12. 2007
38. Dejan Lesjak
39. Erik Margan

* Full-time faculty member

** Part-time faculty member

*** Member of industrial or other organisation

DEPARTMENT OF INORGANIC CHEMISTRY AND TECHNOLOGY K-1

The Department of Inorganic Chemistry and Technology is one of the leading groups in the world in the field of the synthesis of new inorganic compounds containing fluorine. The main research fields are: reactions in superacids, the chemistry of noble gases, the chemistry of the elements of the main groups and the synthesis of new inorganic materials with special properties. A great deal of the activity of the group has been devoted to the technological and ecological problems in Slovenia. The group has already been closely cooperating with Slovenian industry for more than thirty years, is active in the field of educating teachers of chemistry, and promotes natural sciences among students at colleges and elementary schools.



Head:
Dr. Tomaž Skapin

In the field of new inorganic compounds containing fluorine, new coordination compounds of the type $[M^x(L)_n](AF_6)_x$ (M is a metal, e.g., Mg, Ca, Sr, Ba, Cd or a lanthanide element; A is P, As, Sb, Bi, Ta, or Ru; L is a ligand, e.g., XeF_2 , XeF_4 , AsF_3 , or HF and x is the oxidation number of the central atom) have been synthesized.

In connection with this the compounds $[M(XeF_2)_3](PF_6)_2$ (M = Sr, Pb) should be mentioned. These two compounds are isostructural with the compound $[Sr(XeF_2)_3](AsF_6)_2$. If an excess of XeF_2 is used, the compounds $[Pb_3(XeF_2)_{11}](PF_6)_6$ and $[Sr_3(XeF_2)_{10}](PF_6)_6$ can be synthesized. The first compound contains two crystallographically different lead atoms, of which one has a unique homoleptic environment of eight XeF_2 molecules, while the other has a coordination number of 9. In the case of strontium there are also two crystallographically different Sr atoms, but in both cases with a coordination of 9. The reason for the lower coordination number of lead, when compared with strontium, is the higher absolute electronegativity of Sr^{2+} relative to Pb^{2+} . In the scope of a cooperation with the University of Lethbridge, Alberta, Canada, our compounds $[Mg(XeF_2)_2](AsF_6)_2$, $[Mg(XeF_2)_4](AsF_6)_2$, $[Ca(XeF_2)_{2,5}](AsF_6)_2$, $[Ba(XeF_2)_3](AsF_6)_2$, and $[Ba(XeF_2)_5](AsF_6)_2$ were additionally characterized by solid-state ^{19}F and ^{135}Xe magic-angle spinning NMR spectroscopy.

Research into the possibility of using XeF_4 as a ligand was started. The first compound of this type, $[Mg(XeF_2)(XeF_4)](AsF_6)_2$, was prepared, and its structure was determined. In this compound two molecules of xenon fluorides in different oxidation states (XeF_2 , XeF_4) are acting as ligands. The compounds where HF is acting as a ligand or where HF forms with a F anion (poly)-hydrogen-fluoride anions of the type $H_xF_{x+1}^-$ should be mentioned here. In 2007 two new compounds with HF acting as a ligand were isolated and characterized: $[Sr(HF)_3](TaF_6)_2$ and $[Sr(HF)_2](BF_4)_2$. After the compound $Ba(H_3F_4)$, which was isolated and its structure determined in 2006, the compound $Ca(HF_2)_2$ represents the second known compound in which the central atom has a homoleptic environment of HF molecules. Furthermore, ribbon-like polymeric compounds of the type $(MF)_n^+$ were synthesized. These ribbons could be further connected with HF_2^- anions in double ribbons, e.g., $Ba_4F_4(HF_2)(PF_6)_3$ or in infinite layers, e.g., $Pb_2F_2(HF_2)(PF_6)$. During work with anhydrous HF as a solvent and BF_3 as a Lewis acid the compounds $M(BF_4)_2$ where M = Sr and Ba were isolated and structurally characterized.

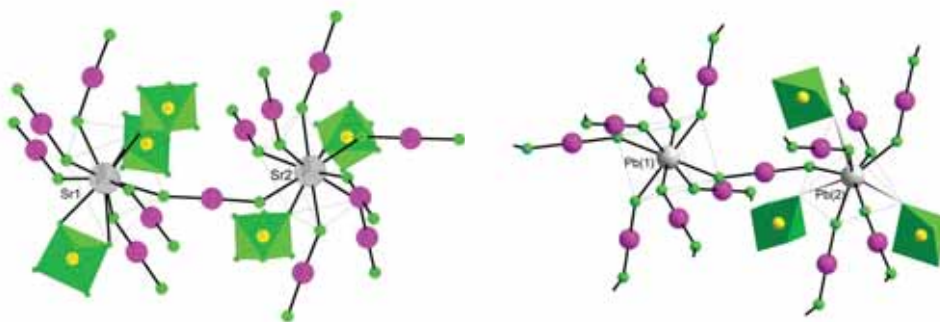


Figure 1: Coordination sphere around the central atom in the compounds $[Sr_3(XeF_2)_{10}](PF_6)_6$ (left) and $[Pb_3(XeF_2)_{11}](PF_6)_6$ (right).

At the 234 ACS National Meeting in Boston a two-day symposium “Novel Bonding and Structural Modalities in Inorganic Fluorine Chemistry” was organized in honour of Prof. Neil Bartlett on the occasion of his 75th birthday. He is an Associated Member of the “Jožef Stefan” Institute and an Honorary Doctor at the University of Ljubljana.

In the system MF_4/XeF_2 the compounds $3\text{XeF}_2 \cdot 2\text{MnF}_4$ and $\text{XeF}_2 \cdot \text{MnF}_4$ were isolated and their structures were determined. A whole series of new metal (Ca, Ba, Sr, Pb) heptafluorotantalates(V) were isolated in a reaction between the corresponding binary fluoride, Ta and fluorine or between binary fluoride and TaF_5 in the proper molar ratio and in anhydrous HF as a solvent. All the Ta atoms possess a distorted pentagonal-bipyramidal environment with Ta-F distances of 1.878–2.044 Å.

Products in the systems AF/CrF_4 and AF/CrF_5 were investigated. ACrF_6 (A = Na, K-Cs), ACrF_5 (A = K-Cs), $\text{A}_2\text{CrF}_6 \cdot 2\text{HF}$ (A = Na, K), $\text{A}_2\text{CrF}_6 \cdot 4\text{HF}$ (A = Rb, Cs), Li_2CrF_6 and $\text{K}_3\text{Cr}_2\text{F}_{11} \cdot 2\text{HF}$ were synthesized and their crystal structures were determined. Polymorphism has been found for NaCrF_6 (orthorhombic and trigonal phases). The crystal structure of $\text{K}_3\text{Cr}_2\text{F}_{11} \cdot 2\text{HF}$ revealed the rare case of a $[\text{M}_2\text{F}_{11}]^{3-}$ anion.

Together with researches from Moscow State University, Russia, we have continued to study the selective fluorination of fullerenes. The fluorination of C_{60} with KMnF_4 yields a mixture of fluorofullerenes, from which single crystals of $\text{C}_{60}\text{F}_{16} \cdot \text{C}_{60}$ were isolated and their crystal structure determined.

With the Aichi Institute of Technology, Nagoya, Japan, we studied the electrochemical behaviour of surface-modified petroleum cokes in propylene-carbonate-containing solvents. Additionally, the surface-structure change and the charge/discharge behaviour of petroleum cokes surface-modified by thermally activated ClF_3 and NF_3 were investigated.

Using polymerization in a plasma the wettability of textile material was modified. Cotton and polyester fabrics were exposed to radio-frequency plasmas of the gases SF_4 , CF_4 , C_6F_{12} and C_6F_{14} . In the cases of using SF_4 or CF_4 as plasma gases,

the surface of the textile fabric became fluorinated, but when using C_6F_{12} or C_6F_{14} the deposition of the fluorocarbon layer took place. AFM images revealed topographic changes and the formation of microstructures in the fabric exposed to plasma, which inhibit water droplets from spreading over the surface. An additional effect is contributed by the composition of the surface of the material. The strongest hydrophobic effect was observed in samples exposed to a radio-frequency plasma of C_6F_{14} gas.

Research within the European project FUNFLUOS was extended to the preparation of GaF_3 with a high surface area. The previously developed oxidative decomposition of hydrazinium(2+) fluoroaluminate, $\text{N}_2\text{H}_6\text{AlF}_5$, was used in the case of a gallium compound, $\text{N}_2\text{H}_6\text{GaF}_5$. The sol-gel route for the preparation of GaF_3 was applied by adding HF in gaseous form to alcoholic solutions of gallium alkoxides. This method gave excellent results. Because of the impurities in commercially available gallium isopropoxide a purification

method involving condensation at higher temperatures was developed. The influence of the HF concentration in the reaction mixture on the surface of the material was tested. Investigations of the mechanism of HS-CrF_3 preparation were continued. Efforts were directed towards finding a suitable iron-containing starting material.

In cooperation with the Department of Solid State Physics (F-5) research on ferroelectric and ferromagnetic metal fluorides has begun. Most of our research was made on $\text{K}_3\text{Fe}_5\text{F}_{15}$, which exhibited both properties.

In addition to a determination of the elemental compositions of some compounds synthesized in our laboratory the chemistry of aluminium fluoro-hydroxy species was studied. Based on the method for determining the total amount of fluorine in organic matter and food developed in our laboratory a total daily intake of fluorine from different sources for humans and its impacts on health were estimated. An overview of the use of oximes, hydroxamic acids and related species as reagents in inorganic analytical chemistry was made. Thermochemical studies on the enthalpies of formation of some aqueous anions were conducted.

A computer program combining physical and chemical models of absorption for the computation of fluid dynamics in a flue-gas scrubber is under development. The program will be useful for the dimensional and efficiency optimization of the scrubber. A method for integrally assessing the suitability of technology optimization alternatives was developed for the flue-gas desulphurization example, quantitatively considering the impacts on the performance, the economy and the reliability of the proposed alternatives under consideration, on which we published a paper in a scientific journal and contributed at a scientific conference. Furthermore, methods for process-reliability assessment were also successfully used for a hydrogen fuel-cell system (PEM type) development, specifically aiming for operability analysis, reliability assessment/engineering, identification of critical components and system optimization.



Figure 2: Symposium in honour of Prof. Neil Bartlett on the occasion of his 75th birthday; Prof. Boris Zemva was one of the organisers.

Within the EU 6FP CA project SHAPE RISK (<http://shaperisk.jrc.it>) we were engaged in the preparation of the final work package *Radical changes, breakthrough and prospective*. The results of the project were and will be presented to related scientific, technical and policy-making audiences. The results will also be used in the preparation of priorities for the 7FP and for potential revisions and implementation of legislation and directives at the EU level, directives 96/82/EC (Seveso II), 96/61/EC (IPPC), and 89/391/EEC (Atex), on which we published a paper in a scientific journal and contributed at a scientific conference.

Regarding major accident hazards, we were engaged by industrial companies. Petrol d.d. commissioned the preparation of a preliminary safety report used in the licensing process. Istrabenz plini d.o.o. commissioned the preparation of an introduction, a description and examination documentation for the training of employees related to safety management system (process safety or prevention of major industrial accidents involving dangerous substances) topics, and the preparation of a safety plan for integrated security management related to the road transportation of hazardous materials (implementation according to the European treaty on the road transport of dangerous goods - ADR).

In 2007 the project entitled "Control of mercury and some other toxic metals emission from power boilers, cement works and other high-temperature industrial processes" (L2-9023-0106-06) started together with the Department of Environmental Sciences. In the first year the focus was on producing the mass balance of contaminants in thermal power production and in cement production. The work is co-financed by the firm ESOTECH. With ESOTECH the research and development project on the so-called "low-cost flue-gas desulphurization (FGD) process" is being continued, with the preparation of a doctoral thesis included. The same subject is also part of a bi-lateral Sino-Slovenian scientific and technical cooperation for the years 2007–2009 between the IJS and the Institute of Thermal Power Engineering, Zhejiang University, Hangzhou.

In the project "Water use optimisation in the thermoenergetics" research was concluded on the FGD process using SO₂ absorption into a saturated ammonium sulphate solution with aqueous ammonia as the neutralizing agent. The second theme in this project was the separation of organic additives, enhancing the absorption rate, from the absorbing solution in a FGD process in order to save the reagent and to decrease the emissions into water to well below permissible limits.

Basic engineering for waste-water purification in the ACRONI steel works was developed and implemented in an industrial waste-water purification plant; the customer finally took over the plant in November 2007 after many successful demonstrations of the effectiveness of the plant.

In cooperation with the Radiation Protection Group at the JSI a major decontamination of old facilities was finished. We have also prepared larger quantities of a uranium compound for export. With all these activities we have additionally proved to have a qualified team for the manipulation of radioactive waste and other radioactive materials.

In cooperation with S&T Slovenija we have developed an information system for the quality control of ammunition for the Slovenian Army, which will incorporate the developed categorisation system. The ammunition categorisation takes safety, technical and tactical properties into account. The result of the categorisation is a proposal for the preferential use of ammunition (e.g., for the needs of training or manoeuvres), and in the case of breaching the predefined limits of safety characteristics the information system automatically demands the exclusion and destruction of the ammunition.

The School of Experimental Chemistry, which is co-financed by the Ministry of Higher Education, Science and Technology organized 42 courses of chemical experiments and attractive experiments at special visits to our laboratories for the students of elementary schools and colleges. In the frame of the promotion of science, partially financed by the Ministry of Higher Education, Science and Technology we visited several elementary schools and colleges across Slovenia and participated during presentations of school books to chemistry teachers. We took part in the Festival of Science in Ljubljana (18–20 September 2007) organized by the Slovenian Scientific Foundation, where we received the Order of Excellency for our workshops. We were invited to the 2007 International Science Festival in Genova, Italy, where our presentations were enthusiastically accepted. With popular-science contributions we participated in the activities of the Mladinska knjiga publishing house.

Good cooperation with industry is based primarily on the trust gained with persistent work over several years. The successful cooperation between the JSI and ESOTECH continued in 2007.



Figure 3: Handling of radioactive waste

The European Union is promoting education in natural sciences, beginning with nursery schools. It is believed that starting later would be too late. The School of Experimental Chemistry is working in agreement with these directions. Some of its activities are already performed in nursery schools.



Figure 4: Cooperation between the JSI and ESOTECH: Reconstructed waste-water purification plant in the ACRONI steel works Jesenice (left), outlet of the purified waste water (right).

Some outstanding publications in 2007

1. T. Bunič, M. Tramšek, E. Goreshnik, G. Tavčar, B. Žemva, Metal(II) hexafluorophosphates(V) (M = Sr, Pb) containing XeF₂-coordinated metal ions [M(XeF₂)₃](PF₆)₂, [Pb₃(XeF₂)₁₁](PbF₆)₆, and [Sr₃(XeF₂)₁₀](PF₆)₆, *Inorg. Chem.*, 46 (2007) 5276–5282.
2. M. Gerken, P. Hazendonk, A. Iuga, J. Nieboer, M. Tramšek, E. Goreshnik, B. Žemva, S. Zheng, J. Autschbach, Solid-state NMR spectroscopic study of coordination compounds of XeF₂ with metal cations and the crystal structure of [Ba(XeF₂)₅][AsF₆]₂, *Inorg. Chem.*, 46 (2007) 6069–6077.
3. K. Naga, T. Nakajima, S. Aimura, Y. Ohzawa, B. Žemva, Z. Mazej, H. Groult, A. Yoshida, Electrochemical behavior of surface-modified petroleum cokes in propylene carbonate containing solvents, *J. Power Sources*, 167 (2007) 192–199.
4. K. Naga, T. Nakajima, Y. Ohzawa, Z. Mazej, B. Žemva, H. Groult, Surface-structure change and charge/discharge behavior of petroleum cokes surface-modified by thermally activated ClF₃ and NF₃, *J. Electrochem. Soc.*, 154 (2007) A347–A352.
5. T. Bunič, M. Tramšek, E. Goreshnik, B. Žemva, Metal (Ca, Ba, Sr, Pb) heptafluorotantalates(V): synthesis, Raman spectra and crystal structures, *Solid State Sci.*, 9 (2007) 88–94.
6. I. Hrstel, M. Gerbec, A. Stergaršek, Technology optimization of wet flue gas desulfurization process, *Chem. Eng. Technol.*, 2007, vol. 30, 220–233.
7. N.J. Duijm, C. Fievez, M. Gerbec, U. Hauptmanns, M. Konstandinidou, Management of health, safety and environment in process industry, *Safety Sci.* (2007), doi:10.1016/j.ssci.2007.11.003.
8. M. Ponikvar, V. Stibilj, B. Žemva, Daily dietary intake of fluoride by Slovenian Military based on analysis of total fluorine in total diet samples using fluoride ion selective electrode, *Food Chem.*, 103 (2007) 369–374.
9. M. Ponikvar, J.F. Liebman, Paradigms and paradoxes: patterns and estimation of the entropy of formation of aqueous hydrogen containing mono and polynuclear oxyanions, *Struct. Chem.*, 18 (2007) 409–413.
10. M. Remškar, J. Kovač, M. Viršek, M. Mrak, A. Jesih, A. Seabaugh, A. W₅O₁₄ nanowires, *Adv. Funct. Mater.*, 17 (2007) 1974–1978.
11. M. Viršek, A. Jesih, I. Milošević, M. Damjanović, M. Remškar, Raman scattering of the MoS₂ and WS₂ single nanotubes, *Surf. Sci.*, 601 (2007) 2868–2872.

Awards and appointments

1. Experimental School of Chemistry: Award from Slovenian science festival: Star of the festival (Sept 2007)

Organization of conferences, congresses and meetings

1. FORM-IT, Meeting of partners, Zreče, 21. –23. 11. 2007

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Patterns and estimation of the entropies of formation of fluorine containing aqueous anions
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Avdoshenko, Vitalii Yu Markov, Zoran Mazej, Lev Nikolaevich Sidorov, Sergey I. Troyanov
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- Maja Ponikvar
Dovolj ali preveč fluora
In: *Kem. šoli, Letn.* 19, No. 1, pp. 27-34, 2007.

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- Iztok Hrastel, Marko Gerbec, Andrej Stergaršek
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In: *Risk, reliability and societal safety: proceedings of the European Safety and Reliability Conference 2007, (ESREL 2007)*, Stavanger, Norway, 25-27 June 2007, Terje Aven, ed., Jan Erik Vinnem, ed., London [etc.], Traylor & Francis, 2007, Zv. 2, pp. 2305-2312.
- V. V. Malyshev, A. I. Gab, L. V. Ursulyak, Melita Tramsšek, Evgeny Goreschnik
Molybdenum and tungsten coatings structure control by means of atmosphere changes above a bath and non-stationary current conditions usage
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- A. Mrzel, M. Remškar, M. Viršek, A. Jesih
The process for the synthesis of quasi onedimensional structures of dichalcogenides and oxides of transition metals: patent application No. 200700233.
Ljubljana: The Slovenian Intellectual Property Office, 2007.
- A. Mrzel, M. Remškar, A. Jesih, M. Viršek
The process for the synthesis of nanotubes and fullerene like nanostructures of dichalcogenides of transition metals: patent application No. P-200700081.
Ljubljana: The Slovenian Intellectual Property Office, 2007.
- M. Remškar, M. Viršek, M. Kocmur, A. Jesih
The process for the synthesis of fibrous tungsten oxide W₅O₁₄: patent application No. P-200700045.
Ljubljana: The Slovenian Intellectual Property Office, 2007.

INTERNATIONAL PROJECTS

- Form-It "Take Part in Research"
Form-It, 6. FP
SAS6, 042938
EC; Markus Meissner, Austrian Institute for Applied Ecology, Vienna, Austria
Tomaž Ogrin, M. Sc.
- Functionalised Metal Fluorides
FUNFLUOS, 6. FP
NMP3-CT-2004-505575
EC; Humboldt-Universität zu Berlin, Berlin, Germany
Dr. Tomaž Skapin
- Sharing Experience on Risk Management (Health, Safety, Environment) to prepare Future Industrial Systems

- SHAPE-RISK, 6. FP
NMP2-CT-2003-505555
EC; Institut National de l'environnement industriel et des risques, Verneuil en Halatte, France
Asst. Prof. Marko Gerbec, Asst. Prof. Branko Kottič
- Worldwide Remediation of Mercury Hazards through Biotechnology
BIOMERCURY, 6. FP
NMP2-CT-2004-505561
EC; Gesellschaft für Biotechnologische Forschung MBH, Braunschweig, Germany
Dr. Andrej Stergaršek, Prof. Milena Horvat
 - Problem-based Learning in Vocational Science - Designing Activities that develop the Skills used by Scientists in the Workplace for Integration into Vocational Science Courses
PROBASE, Leonardo da Vinci Programme
HU/06/B/F/PP-170027
Léványé Szalay Luca, Bertalan Zsolt, Petrik Lajos Két Tanítási Nyelvű Vegyipari, Környezetvédelmi és Informatikai Szakközépiskola, Budapest, Hungary
Tomaž Ogrin, M. Sc.

6. Improvement of the Management of Institutional Radioactive Waste in Slovenia
11145406-06-01-0001
Agency for Radwaste Management, Ljubljana, Slovenia; Leniko bvba, Antwerp, Belgium
Dr. Gašper Tavčar
7. Optimization of Flue Gas Desulphurization (FGD) Process in Iron Ore sintering Plants and Lead/Zinc Smelters
BI-CN/07-09-020
Prof. Xiang Gao, State Key Laboratory of Clean Energy Utilization, Institute of Thermal Energy and Power Engineering, Zhejiang University, Zhejiang Province Hang Zhou, China
Dr. Andrej Stergaršek
8. Experimental and Theoretical Studies of Molecular Adsorption on High Surface Area Materials and Other Interaction Phenomena Relevant to Heterogeneous Catalysis
BI-MK/07-08-003
Prof. Trajče Stafilov, Institute of Chemistry, Faculty of Natural Sciences and Mathematics, University "St. Cyril and Methodius", Skopje, The Republic of Macedonia
Dr. Tomaž Skapin
9. Development of Low Cost Flue Gas Desulphurization (FGD) Technology
BI-RO/05-06/005
Boita Corina, B. Sc., Institute for Studies & Power Engineering (ISPE), Bucharest, Romania
Dr. Andrej Stergaršek
10. Pi-complexes of Copper (I) Fluoro-ionic Salts: Syntheses and Crystal Structure Determinations
BI-UA/07-08-011
Dr. Marian Mys'kiv, Chemical Department, Ivan Franko National University, Lviv, Ukraine
Dr. Zoran Mazej
11. Molybdenum and Tungsten Carbides, Titanium and Zirconium Diborides: Obtained from Fluoride Melts, Structure and Properties
BI-UA/07-08-003
Dr. Viktor Malyshev, Faculty of Chemistry and Technology, National Technical University of Ukraine, "Kyiv Polytechnical Institute", Kiev, Ukraine
Dr. Melita Tramšek
12. Study of Polymerization Process in RF Plasmas
BI-CS/06-07-022
Prof. Zoran Petrović, Institute of Physics, Zemun, Beograd, Serbia
Dr. Adolf Jesih

R & D GRANTS AND CONTRACTS

1. Development of an ammunition categorisation system with implementation into the Quality Manager and Warehouse Management system
Dr. Robert Kocjančič
2. Metal fluorides with specific surface properties
Prof. Boris Žemva
3. Smart functional coatings for improvement of structures and components used in defensive purpose
Dr. Adolf Jesih
4. Control of Hg and some other toxic elements emissions from TPP, cement works and other high-temperature industrial processes
Dr. Andrej Stergaršek

RESEARCH PROGRAM

1. Inorganic Chemistry and Technology
Prof. Boris Žemva

VISITORS FROM ABROAD

1. Prof. dr. Karl O. Christe, University of Southern California, Los Angeles, USA, 27. - 30. 9. 2007
2. Dr. Alexander A. Kolomeitsev, University of Bremen, Hansa Fine Chemicals GmbH, Bremen, Germany, 9. - 11. 10. 2007
3. Dr. Sebastian Riedel, University of Helsinki, Finland, 12. - 14. 11. 2007
4. Prof. dr. Marian Mys'kiv, Ivan Franko National University, Faculty for chemistry, Lviv, Ukraine, 09. 12 - 14. 12. 2007

STAFF

Researchers

1. Asst. Prof. Marko Gerbec
2. Dr. Yevheniy Horyeshnik
3. Dr. Adolf Jesih
4. Asst. Prof. Robert Kocjančič
5. Dr. Zoran Mazej
6. Asst. Prof. Maja Ponikvar
7. **Dr. Tomaž Skapin, Head**
8. Dr. Andrej Stergaršek
9. Dr. Melita Tramšek
10. Prof. Boris Žemva**

Postdoctoral associates

11. Dr. Gašper Tavčar

Postgraduates

12. Tina Bunič, B. Sc.
13. Peter Frkal, B. Sc.
14. Tine Oblak, B. Sc.
15. Tomaž Ogrin, M. Sc.

Technical and administrative staff

16. *Neda Hanc - retired since 3.7. 2007*
17. Pero Kolobaric
18. Robert Moravec
19. Marija Toplak
20. Mira Zupančič

** Part-time faculty member

DEPARTMENT OF PHYSICAL AND ORGANIC CHEMISTRY

K-3

Basic research in the department is focused on experimental and theoretical studies of various physico-chemical processes at surfaces and in atmospheric chemistry. The main attention in the field of organic chemistry is directed to halogenated and, in particular, fluorinated organic molecules.

The experimental research in the field of electrochemistry continues with the materials that are important in biomedical and technological applications. Among the copper alloys, we were mostly focused on the study of nickel silver, Cu-18Ni-20Zn, which is used for the manufacture of fashion jewellery. Nickel deserves special attention, being one of the most frequent contact allergens. We have found that the concentration of nickel after 30 days immersion in artificial sweat exceeds, by more than 500-fold, the threshold limit set by the EU standard BS EN 1811. We have performed basic electrochemical studies on the Cu-18Ni-20Zn alloy and compared its behaviour to that of the binary Cu-xZn and Cu-xNi alloys. In the field of corrosion protection we are interested in various ways of protecting – from corrosion inhibitors to surface layers. From among the available corrosion inhibitors, benzotriazole and its derivatives were studied in detail. In addition to electrochemical methods and an electrochemical nanobalance (EQCN), we used theoretical calculations, as described below. We are primarily interested in the correlation between inhibitor efficiency and the molecular properties of the inhibitor. In the field of corrosion protection with surface coatings, we mostly studied the Al- and Fe-based alloys used in the aero and military industries. The research is carried out in collaboration with the Department of Thin Films and Surfaces (F-3), where the coatings are prepared using the plasma-vapour-deposition (PVD) process. Besides electrochemical methods, we use a chamber for salt-spray testing, which is more appropriate for the testing of the long-term corrosion stability of the prepared coatings (Figure 1).

Our experimental studies of biomedical materials were focused on total hip replacements (THRs) and were carried out in collaboration with the Orthopaedic Hospital Valdoltra and the Faculty of Medicine. Our interest in the large group of Sikomet metal-on-metal THRs continues. With such systems, aseptic loosening remains the major reason for failure. The histological findings and the prevalence of osteolysis suggest the possibility of a hypersensitivity-like immunological response to wear particles. We also studied the clinical performance of THRs with ceramic-on-ceramic articulation, which are alternative bearings to traditional ceramic-on-polyethylene bearings.

Our theoretical physico-chemical investigations were focused on the trends in the equilibrium geometries, torsional frequencies, conformational barriers and relative stabilities for a series of halogenated methyl peroxy nitrites, $CX_nY_{3-n}OONO$ ($X,Y=H, F, Cl$), using density functional and ab-initio theoretical methods. A comparison of the results for the methylperoxy derivatives demonstrates the strong influence of the halogen-withdrawing effect, on both the structural parameters as well as on the energetics, leading to higher relative stability values and a significant lowering of the conformational barriers for the halogenated species. The significance of the results for the kinetics of the $CX_nY_{3-n}OO + NO$ reactions ($X,Y=H, F, Cl$) has been discussed.

We have continued with the ab-initio investigation of the elementary processes on transition-metal surfaces using density functional theory (DFT) electronic structure calculations. The adsorption and thermal decomposition of nitrous oxide, N_2O , with a monocrystal Rh(100) surface have been investigated. N_2O is an intermediate in the removal of NO_x from automobile three-way catalysts. Its decomposition on rhodium and palladium has attracted much attention, because these metals are good catalysts and N_2O is the main by product in the process. The calculations predicted several stable adsorption species, where N_2O either adsorbs in a perpendicular form with the terminal N atom attached to the surface, or lies horizontally on the surface in a bent configuration. The predicted dissociation barrier for N_2O decomposition to atomic oxygen and a nitrogen molecule is very small on the Rh(100), in accordance with the experimental observations.



Head:
Dr. Ingrid Milošev

Our young researcher Tadeja Kosec was awarded first prize in the Harvey Herro for Applied Corrosion Technology competition at the NACE (National Association of Corrosion Engineers) conference Corrosion 2007 in Nashville, USA. The study was devoted to the release of nickel from a Cu-18Ni-20Zn alloy used for the manufacture of fashion jewellery.

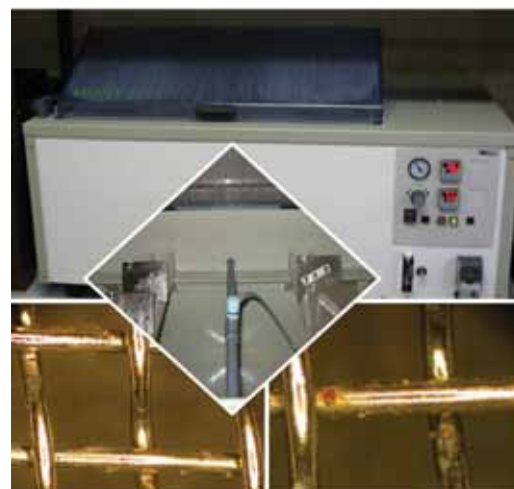


Figure 1: Salt-spray chamber for testing the corrosion resistance of various samples. The inset shows the interior of the chamber with test samples. Corrosion damage caused by the test is depicted below on microscopic images.

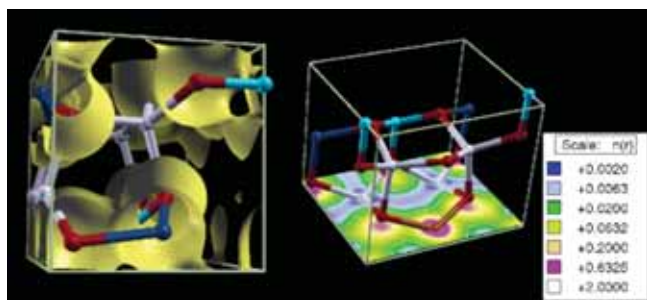


Figure 2: Crystal unit cell of the $\text{Li}_2\text{MnSiO}_4$ compound (Li is coloured white, Mn is dark-blue, Si is cyan, and O is red) and the valence electron density. Notice the extremely small electron density in the regions around the Li atoms, indicating that Li is ionized (Li^+ cation).

We have also investigated by means of DFT calculations two compounds from a new class of potential Li-cathode materials, $\text{Li}_2\text{MnSiO}_4$ and $\text{Li}_2\text{FeSiO}_4$. Although $\text{Li}_2\text{MnSiO}_4$ has been identified recently as a very promising cathode for Li-battery materials, the actual experiments have not confirmed these expectations, presumably due to the poor electronic conductivity of the compound. Using computer simulations based on the DFT we showed instead that the poor electrochemical performance of $\text{Li}_2\text{MnSiO}_4$ stems from its structural instability upon delithiation. Based on the insight gained from the computer simulations, we proposed that a stable material with a reversible exchange of more than one Li ion per formula unit could be obtained by using an appropriate Mn/Fe mixture with the general formula $\text{Li}_2\text{Mn}_x\text{Fe}_{1-x}\text{SiO}_4$ (Figure 2).

By means of DFT simulations we have started to investigate the influence of the electronic structure of corrosion inhibitors on their efficiency. Within this framework we have studied the interaction of a benzotriazole (BTAH) inhibitor with the Cu(111) surface in the adsorption configuration, where the molecule is bonded perpendicularly to the surface with two nitrogen atoms. We have also modelled the adsorption of atomic chlorine on Cu(111). Simulations predict that the most stable configuration is the so-called $\sqrt{3}\times\sqrt{3}$ $R30^\circ$ overlayer of Cl that was observed experimentally at a $1/3$ monolayer coverage.

We proved that the carbon-fluorine bond in organic compounds could be selectively and efficiently formed under solvent-free reaction conditions using N-F reagents.

In the field of organic and bio-organic chemistry we continued our research on the application of green reaction conditions to the selective and efficient halogenation of organic compounds. We proved that the strongest single bond in organic compounds, i.e., the carbon-fluorine bond, could also be selectively and efficiently formed under solvent-free reaction conditions (SFRC) using N-F electrophilic fluorination reagents: *Selectfluor*TM F-TEDA- BF_4 or *Accufluor*TM NFSi. We transformed a variety

of 1,3-dicarbonyl compounds and activated aromatics into their fluorinated derivatives under SFRC using these two N-F reagents. We developed a method for the synthesis of α -brominated ketones using HBr/30% aqueous H_2O_2 in an aqueous media. The method closely mimics the corresponding natural process and represents a green alternative to known methods for the bromination of organic compounds. With an extended study of the halogenation of organic compounds under SFRC using N-halosuccinimides we investigated and evaluated the important parameters regulating reaction processes under these conditions. We established the important effect of the constants of enolization on the reaction's course, but its role depends on the structure of the ketone. In the series of acetophenones more enolizable substrates exhibited greater reactivity, but in a series of cyclic ketones the effect was the opposite. We measured the reaction constants of these reactions, thus showing that such measurements could be successfully made also under SFRC. We discovered and developed a new method for the aerobic iodination of organic compounds following the aerobic oxidative activation of molecular iodine catalysed by sodium nitrite (Figure 3). The iodo-transformations of organic compounds were the most efficient and selective in a MeCN solvent at room temperature.



Figure 3: Reaction vessels for an aerobic oxidative iodination of organic compounds. In green chemistry the most favourable oxidant is air at ordinary pressure. The balloons serve as oxygen reservoirs for the chemical reaction of oxidation and, at the same time, variegate the laboratory.

We developed a new method for the synthesis of geminal hydroperoxides, following the transformation of the carbonyl functional group using 30% aqueous H_2O_2 in the presence of catalytic amounts of molecular iodine. We thus efficiently synthesized a variety of structural types of geminal hydroperoxides from the corresponding ketones or aldehydes. We measured the reaction constant for the transformation of substituted benzaldehydes into geminal hydroperoxides and postulated the mechanism of this reaction.

Some outstanding publications in 2007

1. I. Milošev and T. Kosec, Study of Cu-18Ni-20Zn nickel silver and other Cu-based alloys in artificial sweat and physiological solution, *Electrochim. Acta*, 52 (2007), 6799–6810
2. A. Lesar, Z. Salta, S. Kovačič and A. M. Kosmas, Theoretical characterization of halogenated methylperoxy nitrites $\text{CX}_3\text{Y}_{3-n}\text{OONO}$ (X,Y=H,F,Cl), *Chem. Phys. Lett.* 446 (2007), 268–275

- A. Kokalj, R. Dominko, G. Mali, A. Meden, M. Gaberšček and J. Jamnik, Beyond one-electron reaction in Li cathode materials: designing $\text{Li}_2\text{Mn}_x\text{Fe}_{(1-x)}\text{SiO}_4$. *Chem. mater.* 19 (2007), 3633–3640
- A. Podgoršek, S. Stavber, M. Zupan and J. Iskra, Bromination of ketones with $\text{H}_2\text{O}_2\text{-HBr}$ “on water”. *Green chem.* 9 (11) (2007), 1212–1218
- K. Žmitek, M. Zupan, S. Stavber and J. Iskra, The effect of iodine on the peroxidation of carbonyl compounds, *J. Org. Chem.* 72 (2007), 6534–6540

Awards and appointments

- Tadeja Kosec: 1st Prize, Harvey Herro for Applied Corrosion Technology, Nashville, USA, NACE (National Association for Corrosion Technology), work “Investigation of Ni release from Nickel Silver” by Tadeja Kosec and Ingrid Milošev
- Sebastijan Peljhan: Prešern student award, Faculty of Chemistry and Chemical Technology, University of Ljubljana, work “Physical and chemical study of aqueous solutions of poly(ethacrylic acid)”

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ORIGINAL ARTICLES

- Robert Dominko, Marjan Bele, Anton Kokalj, Miran Gaberšček, Janko Jamnik
 $\text{Li}_2\text{MnSiO}_4$ as a potential Li-battery cathode material
In: The 11th International meeting on lithium batteries: Biarritz, France, 18-23 June 2006: IMLB-2006 (Journal of power sources, Vol. 174, Issue 2), Lausanne, Elsevier, 2007, Vol. 174, no. 2, pp. 457-461, 2007.
- Matjaž Finšgar, Ingrid Milošev, Boris Pihlar
Inhibition of copper corrosion studied by electrochemical and EQCN techniques
In: *Acta chim. slov.*, Vol. 54, no. 3, pp. 591-597, 2007.
- Anton Kokalj, Robert Dominko, Gregor Mali, Anton Meden, Miran Gaberšček, Janko Jamnik
Beyond one-electron reaction in Li cathode materials: designing $\text{Li}_2\text{Mn}_x\text{Fe}_{1-x}\text{SiO}_4$
In: *Chem. mater.*, Vol. 19, no. 15, pp. 3633-3640, 2007.
- Tadeja Kosec, Ingrid Milošev
Metal ion release and surface composition of the Cu-18Ni-20Zn nickel silver during 30-days immersion in artificial sweat
In: *Appl. surf. sci.*, Vol. 254, pp. 644-652, 2007.
- Tadeja Kosec, Ingrid Milošev
Comparison of a ternary Cu-18Ni-20Zn alloy and binary Cu-based alloys in alkaline solutions
In: *Mater. chem. phys.*, Vol. 104, no. 1, pp. 44-49, 2007.
- Tadeja Kosec, Ingrid Milošev, Boris Pihlar
Benzotriazole as an inhibitor of brass corrosion in chloride solution
In: *Appl. surf. sci.*, Vol. 253, no. 22, pp. 8863-8873, 2007.
- Antonija Lesar, Zoi Salta, Saša Kovacič, Agnie M. Kosmas
Theoretical characterization of halogenated methylperoxy nitrites $\text{CX}_n\text{Y}_m\text{OONO}$ (X, Y = H, F, Cl)
In: *Chem. Phys. Lett.*, Vol. 446, pp. 268-275, 2007.
- Tatsuo Matsushima, Anton Kokalj
Angular distributions of desorbing N_2 in thermal N_2O decomposition on Rh (100)
In: *Surf. sci.*, Vol. 601, pp. 3996-4000, 2007.
- Mirjana Metikoš-Huković, Ranko Babić, Dario Omanović, Ingrid Milošev
The role of alloying elements in the corrosion of cobalt-based alloys
In: *ECS transactions*, Vol. 2, no. 9, pp. 43-57, 2007.
- Ingrid Milošev
The effect of various halide ions on the passivity of Cu, Zn and Cu-xZn alloys in borate buffer
In: *Corros. sci.*, Vol. 49, pp. 637-653, 2007.
- Ingrid Milošev, Tadeja Kosec
Study of Cu-18Ni-20Zn nickel silver and other Cu-based alloys in artificial sweat and physiological solution
In: *Electrochim. acta*, Vol. 52, pp. 6799-6810, 2007.
- Jasminka Pavlinac, Marko Zupan, Stojan Stavber
Solvent-free iodination of organic molecules using the $\text{I}_2/\text{urea-H}_2\text{O}_2$ reagent system
In: *Organic and Biomolecular Chemistry*, Vol. 5, pp. 699-707, 2007.
- Ajda Podgoršek, Stojan Stavber, Marko Zupan, Jernej Iskra
Bromination of ketones with $\text{H}_2\text{O}_2\text{-HBr}$ “on water”
In: *Green chem. (Print)*, Vol. 9, pp. 1212-1218, 2007.
- Katja Žmitek, Marko Zupan, Stojan Stavber, Jernej Iskra
The effect of iodine on the peroxidation of carbonyl compounds
In: *J. org. chem.*, Vol. 72, pp. 6534-6540, 2007.
- Gaj Stavber, Marko Zupan, Stojan Stavber
Solvent-free fluorination of organic compounds using N-F reagents
In: *Tetrahedron lett.*, Vol. 48, pp. 2671-2673, 2007.
- Edita Blažević, Ingrid Milošev
Uporaba dentalnih zlitin za protetične nadomestke in implantante
In: *Vakuumist, Letn.* 27, No. 1/2, pp. 20-23, 2007.
- Matjaž Finšgar, Ingrid Milošev
Ciklična voltametrika - elektrokemijska metoda za študij reakcijskih mehanizmov
In: *Vakuumist, Letn.* 27, No. 3, pp. 16-22, 2007.
- Tadeja Kosec, Ingrid Milošev
Inhibicija korozije bakra in njegovih zlitin s cinkom z benzotriazolom v kloridni raztopini
In: *Vakuumist, Letn.* 27, no. 3, pp. 4-9, 2007.
- Ingrid Milošev
Materiali za biomedicinske aplikacije
In: *Kem. šoli, Letn.* 19, No. 3, pp. 25-36, 2007.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

- Matjaž Finšgar, Ingrid Milošev
Uporaba piezoelektrične kremenove mikrorehtnice
In: *Vakuumist, Letn.* 27, No. 1/2, pp. 34-42, 2007.
- Katja Žmitek, Marko Zupan, Jernej Iskra
 α -substituted organic peroxides: synthetic strategies for a biologically important class of gem-dihydroperoxide and perketal derivatives
In: *Organic and Biomolecular Chemistry*, Vol. 5, no. 24, pp. 3895-3908, 2007.

PUBLISHED CONFERENCE PAPERS

Invited Paper

- Robert Dominko, Miran Gaberšček, Marjan Bele, Gregor Mali, Anton Meden, Darko Hanzel, Anton Kokalj, Janko Jamnik
 Li_2MSiO_4 (M=Fe and/or Mn) cathode materials: [invited lecture]
In: International Battery Materials Association 2007 conference: Shenzhen, China, November 16-20, 2007, [S.I.], International Battery Materials Association, 2007, pp. 14-15.

Regular Paper

- Agnie M. Kosmas, Antonija Lesar
Halogenated methyl nitrates, A computational study of their properties and capacity to act as sink compounds in the troposphere
In: Computational methods in science and engineering: theory and computation: old problems and new challenges: lectures presented at the International Conference on Computational Methods in Science and Engineering 2007 (ICCMSE 2007), Corfu (Greece), 25-30 September 2007 (AIP conference proceedings, v. 963), George Maroulis, ed., Theodore Simos, ed., [S.I.], AIP Springer, 2007, 4 str.

Ph. D. Thesis

1. Tadeja Kosec
Mehanizem inhibicije korozije bakra in njegovih zlitin s cinkom z derivati benzotriazolov v kloridnih raztopinah: doktorska disertacija
Ljubljana, [T. Kosec], 2007.

PATENT APPLICATION

1. European Patent Office, No. of application: 071154322-1521
Title: Process for preparing 2-sulfinyl-1H-benzimidazoles
Authors: Jernej Iskra, Stojan Stavber, Kotar Jordan Berta, Miloš Ružič, Janez Smodiš, Rok Zupet
Applied by: Krka Tovarna zdravil, d.d.

INTERNATIONAL PROJECTS

1. New Fluorous Media and Processes for Cleaner and Safer Chemistry
COST D29 (Working Group 0011-03), EC
Dr. Jernej Iskra
2. Core Laboratories for the Improvement of Medical Devices in Clinical Practice from the Failure of the Explanted Prostheses Analysis (FEPA)
COST Action 537 (WG 1), EC
Dr. Ingrid Milošev
3. Psi-K: Towards Atomistic Materials Design
ESF - European Science Foundation, Strasbourg Cedex, France
Dr. Anton Kokalj
4. A Swedish-Slovenian Nanobattery Network: SVEN-SLO-BATT
Micro-Nano-Technology (MNT) ERA Project
Dr. Anton Kokalj
5. Improvement of Resurfacing Hip Implants with DLC, TiO₂ and DLC-p-h Nanocomposite Coatings
Material (MAT) ERA Project
Dr. Ingrid Milošev
6. Investigation of Elemental Steps of Competing Radical Reactions important for Atmospheric Chemistry, especially Chlorine and Bromine Containing Compounds
BI-AT/07-08-017
Prof. Max Muehlhaeuser, Management Center Innsbruck, Innsbruck, Austria
Dr. Antonija Lesar
7. Fluorous Phases as Substitutes to Organic Solvents. Study of Solvation and Molecular Transport
PROTEUS, BI-FR07-PROTEUS-005
Dr. Margarida Costa Gomes, Laboratoire de Thermodynamique des solutions et des polymères UMR 6003 CNRS/Université Blaise Pascal, Clermont-Ferrand, Aubière Cedex, France
Dr. Jernej Iskra
8. Physicochemical Behaviour of the Atmospheric Pollutants: Reaction of Plain and Chlorinated Methoxy and Methylperoxy Radicals with Nitrogen Oxide
BI-GR/04-06-004
Dr. Agnie M. Kosmas, University of Ioannina, Department of Chemistry, Ioannina, Greece
Dr. Antonija Lesar
9. Theoretical Study of Bioactive Molecules with Property of Nitric Oxide (NO) Release: N nitrosohydroxylamine and its N- and O-alkyl Derivatives
BI-HR/06-07-022
Dr. Mirjana Eckert-Maksić, Rudjer Bošković Institute, Zagreb, Croatia
Dr. Antonija Lesar

10. Chemistry at Silver Surfaces: Understanding Ethylene Epoxidation and Other Peculiar Reactions on Silver based Catalysts
BI-IT/05-08-004
Dr. Mario Rocca, Department of Physics, University of Genova, Genova, Italy
Dr. Anton Kokalj
11. PVD Coatings for Protection of Aluminium-based Substrates for Aircraft Applications
Dr. Michael Pawlik, PPG Industries, Inc., One PPG Place, Pittsburg, Pennsylvania; Rosanna Drive, Allison Park, PA, ZDA
Dr. Ingrid Milošev, Dr. Peter Panjan

R & D GRANTS AND CONTRACTS

1. The influence of electronic structure of corrosion inhibitors on their efficiency
Dr. Anton Kokalj
2. Local and systemic effects of articulation of metal components from total hip replacements
Dr. Ingrid Milošev
3. PVD hard coatings as an alternative for corrosion protection of Fe and Al alloys
Dr. Darinka Kek Merl
4. Smart functional coatings for improvement of structures and components used in defensive purposes
Dr. Peter Panjan

RESEARCH PROGRAMS

1. Bioinorganic and bioorganic chemistry
Dr. Stojan Stavber
2. Micro- and nanostructured functional materials: development, physical and chemical characterization and simulation of processes
Dr. Ingrid Milošev

NEW CONTRACTS

1. Synthesis of pharmaceutically important compounds
Krka, tovarna zdravil, d.d.
Dr. Jernej Iskra, Dr. Stojan Stavber
2. Research on the area of surface active materials
ECOT d.o.o.
Dr. Stojan Stavber

VISITORS FROM ABROAD

1. Prof. Agnie Mylona Kosmas, University of Ioannina, Greece, 26.4. - 29. 4. 2007

2. Malgorzata Figurska, B.Sc., Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland, 11.6. - 22.6. 2007
3. Dr. Margarida Costa Gomes, University Blaise Pascal, Clermont Ferrand, France, 28.10 - 1.11. 2007
4. Prof. Agilio Padua, University Blaise Pascal, Clermont Ferrand, France, 28.10 - 1.11. 2007

STAFF

Researchers

1. Dr. Jernej Iskra
2. Dr. Anton Kokalj
3. Dr. Antonija Lesar
4. **Dr. Ingrid Milošev, Head**
5. Dr. Stojan Stavber
6. Prof. Marko-Andrej Zupan

Postdoctoral associates

7. Dr. Tadeja Kosec
8. *Dr. Lea Županc Mežnar, left 1.6.2007*

Postgraduates

9. Matjaž Finšgar, B. Sc.
10. Saša Kovačič, B. Sc.
11. Jasminka Pavlinac, B. Sc.
12. Sebastijan Peljhan, B. Sc.
13. Ajda Podgoršek, B. Sc.
14. Katja Žmitek, B. Sc.

Technical and administrative staff

15. Edita Blažević, B. Sc.

The Electronic Ceramics Department is active in research associated with the syntheses, properties and applications of materials for electronics, mainly complex multifunctional materials and structures. The materials of interest include ceramic piezoelectrics, ferroelectrics, relaxors, 'conductive' oxides and materials for solid-oxide fuel cells (SOFCs). The emphasis is on the development of properties based on the synthesis and the structure at the nano-, micro- and macro-level.



Head:
Prof. Marija Kosec

New materials: lead-free piezoelectrics. We prepared $(K_{0.5}Na_{0.5})NbO_3$ (KNN) ceramics with the addition of 1 mass % ZrO_2 with the aim to hinder the exaggerated grain growth encountered in KNN sintered in air. Both KNN and KNN- ZrO_2 ceramics sintered at 1115°C and 1125°C, respectively, had relative densities exceeding 95%. The KNN had a bimodal microstructure, with the largest grains being approximately 20 μm , while the microstructure of KNN- ZrO_2 was fine and uniform, with the largest grains being approximately 1.3 μm (Figure 1). The influence of ZrO_2 is twofold: ZrO_2 particles, located at the KNN grain junctions, hinder the matrix grain growth. Additionally, the enrichment of the boundary regions of the matrix grains with Zr, relative to the grain interiors, is also a probable reason for the decreased mobility of the grain boundaries. The dielectric permittivity and losses, measured at 10 kHz, and the piezo d_{33} constant of KNN and KNN- ZrO_2 , are 580, 0.08, 80 pC/N and 905, 0.04 and 100 pC/N, respectively. This research was part of the EU 6FP project MIND.

We continued with our research on the solid-state crystal growth (SSCG) of $K_{0.5}Na_{0.5}NbO_3$ (KNN). Dense, homogeneous single crystals of KNN up to 4 mm in diameter on (110) $KTaO_3$ seeds have been grown in a hot press after 100 hours at 1100°C. The relative permittivity and the dielectric losses as a function of temperature for the KNN single crystal and ceramics were measured. A similar temperature dependence of the permittivity was observed for both materials, with two maxima corresponding to the phase transitions of KNN at around 200°C and 420°C. The relative permittivities of both materials are comparable, while the dielectric losses of the single crystal are lower than for the ceramics (see Figure 2).

Our research also focused on the effect of the addition of the $K_4CuNb_8O_{23}$ (KCN) liquid-phase sintering aid on the growth of single crystals. The results showed that the single-crystal growth rate can be retarded or enhanced by the addition of different amounts of KCN. Single crystals grown using 0.5 mol% KCN were stoichiometric, while in the single crystals grown with 2 mol% KCN the Na/K ratio increased. This research was part of the EU 6FP project IMMEDIATE.

We systematically studied the synthesis of nanoparticles with the aim of controlling the morphology and achieving a high chemical homogeneity. The research on the **sol-gel synthesis of nanoparticles** of multicomponent oxides was focused on $PbZrO_3$ prepared from lead acetate and zirconium butoxide in butanol, and hydrolyzed with different amounts of water in neutral and alkaline media. Using X-ray absorption spectroscopy (EXAFS) we analyzed the local environment of the Pb and Zr atoms in the sol, as-dried (150°C) and heated (400°C) amorphous powders. We confirmed the presence of Pb-O-Zr and a large number of Zr-O-Zr links in the sol. Upon drying and further heating the number of Pb-O-Zr links gradually diminishes, while the Zr-O-Zr links persist. We found that the local environment of the metal atoms was not influenced by the hydrolysis conditions.

High-energy milling or mechanochemical synthesis is one of the promising routes for the synthesis of nanopowders. We continued with our research on the mechanochemical synthesis of $NaNbO_3$ and found that the compound is formed from the amorphous phase through a nucleation-and-growth mechanism. During milling a quasi-equilibrium condition is reached, where the quantitative phase composition and the chemical composition of the powder mixture remain constant. About 50% of the amorphous phase is still present in the mixture, together with nanocrystalline $NaNbO_3$. The morphological

We prepared the first piezoelectric single crystals of $(K_{0.5}Na_{0.5})NbO_3$, taking advantage of the abnormal grain-growth phenomenon in the ceramic.

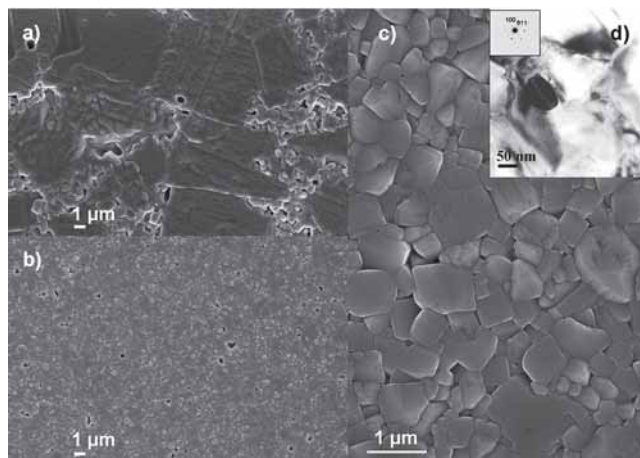


Figure 1: Comparison of thermally etched microstructures of $K_{0.5}Na_{0.5}NbO_3$ (KNN) and KNN- ZrO_2 ceramics (a, b). Microstructure of KNN- ZrO_2 ceramics at a higher magnification (FE-SEM) (c). Bright-field TEM image of a ZrO_2 grain in a [01-1] zone axis located at the junction of KNN matrix grains. Inset: selected-area electron diffraction of the ZrO_2 grain (d).

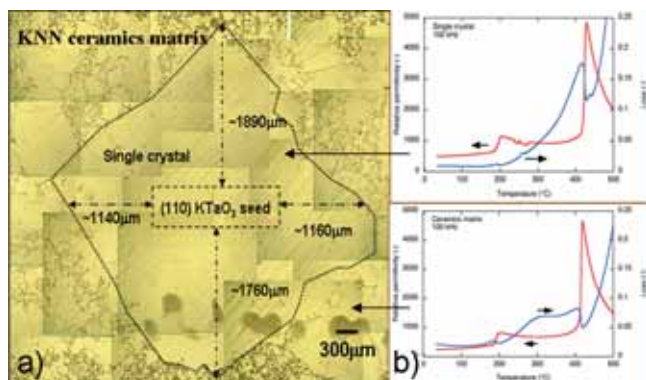


Figure 2: Optical micrographs of a single crystal of KNN grown in a hot press at 1100°C for 100 hours (a). Comparison of the relative permittivity and dielectric loss versus temperature of the KNN ceramic matrix and the single crystal (b).

In our study of the mechanochemical synthesis of NaNbO₃ we found that during milling a quasi-equilibrium condition between the nanocrystalline and amorphous phases is reached.

characteristics of the NaNbO₃ powder, such as the crystallite size and the quantity of microstrains, do not change with a prolonged mechanochemical treatment and do not depend on the applied ball-impact energy.

Our research on the **chemical solution deposition of ferroelectric thin films** focused mainly on (Ba,Sr)TiO₃ and (K_{0.5}Na_{0.5})NbO₃. Cooperation with our partners HYB d.o.o., Šentjernej; EPFL, Switzerland; and Thales, France, in the frame of the EU 6 FP project RETINA led to the successful development and fabrication of high-frequency (10 to 14 GHz) phase shifters for aeronautic applications. Planar capacitors fabricated from Ba_{0.3}Sr_{0.7}TiO₃ thin films on Al₂O₃ substrates with a relative film permittivity of about 700 and a tunability of the total capacitance $n_c = C_{0V}/C_{150V} = 1.7$ (at E = 600 kV/cm) were assembled into a test reflect-array unit cell. Good agreement between the measurements performed in the microwave frequency domain and the simulation results from the design stage was obtained; therefore, the properties of the ferroelectric components to be used in the final partial reflect-array demonstrator were determined (Figure 3). In addition, higher tunability $n_c > 2.5$ (at E = 600 kV/cm) was achieved by increasing the Ba content up to Ba_{0.55}Sr_{0.45}TiO₃.

We prepared (K_{0.5}Na_{0.5})NbO₃ thin films on Pt(111)/TiO₂/SiO₂/Si substrates from alkaline acetates and niobium ethoxide in a stoichiometric ratio. The films crystallize in the perovskite phase upon heating at 670°C. The dielectric permittivity and the losses of approximately 350-nm-thick films, measured at room temperature and at 10 kHz, are 533 and 0.068, respectively.

Thick films based on 0.65Pb(Mg_{1/3}Nb_{2/3})O₃-0.35PbTiO₃ (0.65PMN-0.35PT) with dielectric and ferroelectric properties comparable to bulk ceramics were screen printed and fired **on alumina substrates**. Such good characteristics were obtained using nanosized powders prepared by mechanochemical synthesis and by sintering thick-film structures in a lead-oxide-enriched atmosphere. Dense thick films with excellent functional properties sintered in the temperature range 850–950°C were successfully prepared.

Integrated ultrasonic transducers on porous alumina substrates were developed within the 6FP projects MIND and MINUET. This work is a continuation of the development of integrated ultrasonic transducers on porous ceramic, which serves both as a substrate and as a backing. Previously developed porous Pb(Zr,Ti)O₃ (PZT) ceramics have been successfully replaced with porous alumina. Although the latter has a lower ultrasound damping than PZT, the transducers with both substrates have comparable sensitivities.

We investigated the possibility of preparing films in the micrometer range by electrophoretic deposition (EPD), and also started to study the deposition of films using ink-jet printing.

Transparent, conductive oxides based on ZnO have been studied in order to develop flexible, large-area, low-cost flat-panel displays. The use of a flexible plastic substrate enables the manufacturing of large-area LCD or OLED displays that can be rolled up and saved after use. The technological barriers to be overcome include developing new, transparent materials, developing novel deposition technologies that enable low-temperature, large-area processing on flexible substrates, and developing curing methods in order to produce amorphous material with the desired properties.

Our research on radically new, semiconducting, multicomponent oxide materials based on ZnO, In₂O₃ and Ga₂O₃ that are transparent and have an electrical mobility higher than 50 cm²V⁻¹s⁻¹ is in progress. Thin films with thickness ranges from ten to a few hundreds of nanometers have been prepared by pulsed-laser deposition (PLD) in cooperation with University Nova from Lisbon, Portugal within the EU 6 FP project Multiflexioxides.

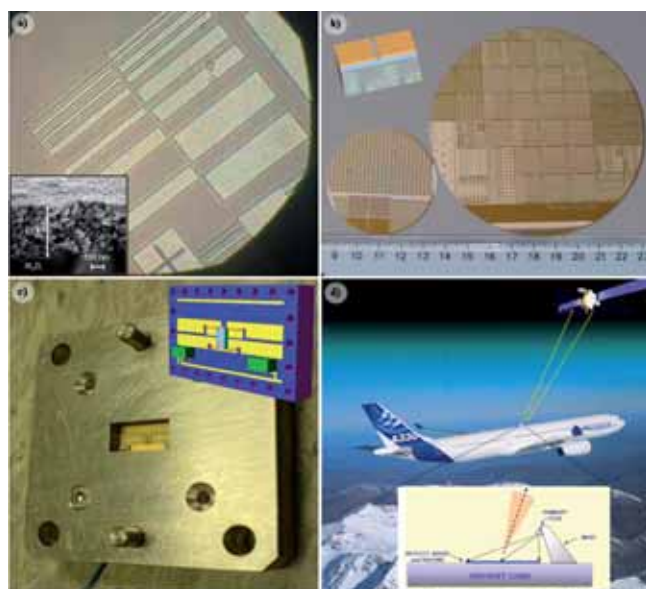


Figure 3: a) Test structures for the verification of the individual processing steps. Bright areas are the openings in a 4.5-µm-thick negative photoresist (darker areas) processed on top of a ceramic Ba_{0.3}Sr_{0.7}TiO₃ thin film made on an alumina substrate. The smallest feature at the start of the scale (line and opening width) is only 1 µm. b) 2-inch and 4-inch alumina wafers with thousands of tunable thin-film capacitors. c) A phase shifter based on a tunable thin-film ferroelectric capacitor (in the centre of the cell) fabricated within the RETINA project in cooperation with partners HYB d.o.o., Thales and EPFL. d) The antenna is designed as a 2D array of ferroelectric phase shifters, which enable electronic steering in the direction of the chosen satellite.

Ceramics with optimal properties developed at the Electronic Ceramics Department have been used as targets for PLD. The obtained thin films are amorphous and have the desired properties.

The precursors for processing amorphous ZnO-based thin films on flexible, organic substrates by chemical solution deposition have been developed. The acetate and nitrate-based precursors have been studied. We have found that amorphous thin films can be produced at 150°C from an acetate-based precursor.

In the field of **phase diagrams**, phase equilibria in the $\text{RuO}_2\text{-Bi}_2\text{O}_3\text{-SiO}_2$ system were investigated. The studies, performed in collaboration with EPFL, Switzerland, are important for understanding the reactions between PbO-free glasses, where PbO is replaced by the low-melting-temperature Bi_2O_3 , in accordance with the RoHS directive, and by a ruthenium-based conductive phase in thick-film resistors. Preliminary experiments showed that RuO_2 is compatible with glasses rich in SiO_2 and Bi_2O_3 , and therefore useful as a conductive phase in lead-free thick-film resistors.

LTCC (low-temperature co-fired ceramics) materials are used for multilayer hybrid circuits and 3D structures (MEMS – micro-electro-mechanical systems) with buried channels and cavities. A new lead-free LTCC material that does not shrink in the x and y dimensions during firing, which means that the dimensions of the unfired and fired structures are the same, was studied. Commercial thick-film resistors with low and high temperature coefficients of resistivity as well as custom-made ferroelectric thick-film materials were fired on these LTCC substrates, and their electrical characteristics were evaluated. As the thick-film materials were developed for firing on relatively inert alumina substrates, the results obtained on LTCC were satisfactory: some characteristics deteriorate; however, they are still in the useful range. This was attributed to the interactions between the rather glassy LTCC substrates and the films, as determined by EDS microanalyses.

The materials, technologies and constructions of ceramic pressure sensors were studied. Three types of sensing principle were estimated and realized, i.e., piezo-resistive, piezo-capacitive and piezoelectric (resonance). For the realization of the different types of pressure sensors, thick-film technology and LTCC structures were chosen. Numerical models for the simulation of the essential parameters of the sensors were prepared. A few prototypes were realized and tested. The construction of a resonance pressure sensor with a piezoelectric active layer on an LTCC membrane deserves special emphasis (see Fig. 4). The collaboration within the European project MINUET contributed significantly to the good results obtained.

Within the scope of the cooperation with our partners HIPOT-RR d.o.o and HYB d.o.o., new materials and technologies conforming to the RoHS directive have been evaluated. Results indicate that the number of faults increases when RoHS-compatible materials are used. In short, further work is needed to optimize the production of thick-film circuits with RoHS-compatible materials.

For the industrial partner HYB d.o.o. thick-film resistor materials for potentiometers were investigated using SEM and EDS. We needed to determine how the technological process was correlated to a large spread of the nominal resistance values.

For the industrial partner Iskratel many different types of defected multilayer capacitors were analyzed using SEM and EDS to ascertain where and why these faults occur. In particular, attention was paid to the interface between the external electrodes and the capacitor material or within the multilayer capacitor itself.

With the company ETI d.d. we cooperated on improving the thermal characteristics of high-alumina porcelain. The aim of the research was to increase the thermal shock resistance of ceramic elements for electrical fuses. This was achieved by adding lithium compounds, which form lithium-aluminosilicate phases with a low thermal expansion coefficient and promote the formation of the mullite phase.

Cooperation with our partners HYB d.o.o., Šentjernej; EPFL, Switzerland; and Thales, France, in the frame of 6 FP EU project RETINA led to a successful development and fabrication of a phase shifter based on a tunable thin-film ferroelectric capacitor, the basic component of the reflect-array antenna designed for microwave, aeronautic telecommunication systems.

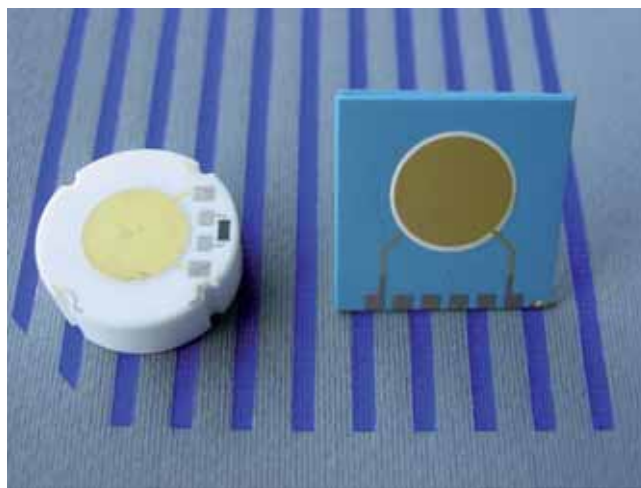


Fig. 4. Thick-film piezoelectric resonant pressure sensors fabricated from the $\text{Pb}(\text{Zr,Ti})\text{O}_3$ ceramic on alumina (left) and LTCC (right) structures.

Cooperation with the research partner HIPOT-RR d.o.o. and the industrial partner HYB d.o.o. resulted in a thick-film piezoelectric resonant pressure sensor. Such a sensor is a relatively new device, made with a new thick-film $\text{Pb}(\text{Zr,Ti})\text{O}_3$ material on a 3D LTCC structure.

The research was conducted in the frame of the research group, two ARRS projects, co-financed by Slovenian industry, two CRP-MIR projects, one project financed by Slovenian industry and nine EU projects.

Some outstanding publications in 2007

1. John Fisher, Andreja Benčan, Janez Holc, Marija Kosec, Sophie Vernay, Daniel Rytz. Growth of potassium sodium niobate single crystals by solid state crystal growth. *J. Cryst. Growth.*, 2007, 303, 487-492.
2. Marko Hrovat, Darko Belavič, Jarosław Kita, Janez Holc, Jena Cilensek, Leszek Golonka, Andrzej Dzedzic. Thick-film PTC thermistors and LTCC structures: the dependence of the electrical and microstructural characteristics on the firing temperature. *J. Eur. Ceram. Soc.*, 2007, 27, 2237-2243.
3. Danjela Kuščer, Janez Holc, Marija Kosec. Formation of $0.65 \text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3}\text{O}_3 - 0.35 \text{PbTiO}_3)$ using a high-energy milling process. *J. Am. Ceram. Soc.*, 2007, 90 [1], 29-35.
4. Barbara Malič, Iulian Boerasu, Mira Mandeljc, Marija Kosec, Vladimir Sherman, Tomoaki Yamada, Nava Setter, Mišo Vukadinović. Processing and dielectric characterization of $\text{Ba}_{0.3}\text{Sr}_{0.7}\text{TiO}_3$ thin films on alumina substrates. *J. Eur. Ceram. Soc.*, 2007, 27 [8/9], 2945-2948.
5. Tadej Rojac, O. Masson, R. Guinebrière, Marija Kosec, Barbara Malič, Janez Holc. A study of the mechanochemical synthesis of NaNbO_3 . *J. Eur. Ceram. Soc.*, 2007, 27 [5], 2265-2271.

Patents granted

1. Marina Santo-Zarnik, Darko Belavič, Marko Hrovat, Marko Pavlin
Patent Number: 22106
Thick film piezoresistive pressure sensor with a floating diaphragm
Hyb d.o.o. and JSI

Awards and appointments

1. Glinšek Sebastjan: Students Preseren Award, B. Sc. thesis entitled »Processing and Characterization of $\text{K}(\text{Ta}, \text{Nb})\text{O}_3$ Thin Films on Al_2O_3 Substrates«
2. Kosec Marija: Inauguration: Guest Professor of Xi'an Jiaotong University, Xi'an, China, January 22, 2007
3. Trefalt Gregor: Students Preseren Award, B. Sc. thesis entitled »Preferential Adsorption of Electrolyte Mixtures in Disordered Porous Media«

Organization of conferences, congresses and meetings

1. Piezoelectricity for end users (PIEZO 2007), Liberec, Czech Republic, February 6 - 9, 2007
2. Expertise Consultation on Advanced Materials and Technologies in Science and Technology at the 40th traditional event of the Faculty of Natural Sciences and Engineering »Skok čez kožo«, Ljubljana, Slovenia, March 30, 2007
3. 2nd Workshop on Integrated Electroceramics Functional Structures, Berchtesgaden, Germany, June 14 - 16, 2007
4. 11th European Meeting on Ferroelectricity (EMF 2007), Bled, Slovenia, September 3 - 7, 2007
5. 10th International Conference and Exhibition of the European Ceramic Society (ECERS 2007), Berlin, Germany, June 18 - 21, 2007
6. International Conference on Electroceramics ICE 2007, Arusha, Tanzania, July 26 - August 5, 2007
7. 43rd International Conference on Microelectronics, Devices and Materials - MIDEM, Bled, Slovenia, September 12 - 14, 2007
8. European Congress on Advanced Materials and Processes (EUROMAT 2007), Nurnberg, Germany, September 10 - 13, 2007
9. 15th International Conference on Materials and Technologies, Portorož, Slovenia, October 8 - 10, 2007

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PUBLISHED CONFERENCE PAPERS

Invited Paper

- Marina Santo-Zarnik, Darko Belavič, Srečo Maček
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Regular Papers

- Uroš Aljančič, Mišo Vukadinović, Drago Resnik, Danilo Vrtačnik, Matej Možek, Samo Penič, Slavko Amon
Cantilever characterization method for static behavior of PZT thin films
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2. Darko Belavič, Marko Hrovat, Hana Uršič, Silvo Drnovšek, Mitja Jerlah, Jena Čilenšek, Janez Holc, Marina Santo-Zarnik, Marija Kosec
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3. Darko Belavič, Marina Santo-Zarnik, Marko Hrovat, Srečo Maček, Marko Pavlin, Mitja Jerlah, Janez Holc, Silvo Drnovšek, Jena Čilenšek, Marija Kosec
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5. Marko Hrovat, Darko Belavič, Jarosław Kita, Janez Holc, Jena Čilenšek, Leszek Golonka, Andrzej Dziedzic
Thick-film temperature sensors and LTCC substrates - evaluation and characterization
In: Emerging technologies for electronics packaging, ISSE 2007, 30th International Spring Seminar on Electronics Technology Cluj-Napoca, Romania, May 9-13, 2007, Piscataway, IEEE, 2007, pp. 65-69.
6. Marko Hrovat, Darko Belavič, Jarosław Kita, Janez Holc, Jena Čilenšek, Leszek Golonka, Andrzej Dziedzic
A study of PTC and NTC thick film thermistors on LTCC substrates
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7. Marija Kosec, Marko Hrovat, Janez Holc, Danjela Kuščer
processing of 0.65 Pb(Mg_{1/3}Nb_{2/3}O₃)-0.35 PbTiO₃ thick-films on LTCC ceramic substrates
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8. Pierre Maréchal, Danjela Kuščer, Franck Levassort, Louis-Pascal Tran-Huu-Hue, Janez Holc, Marija Kosec, Marc Lethiecq
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10. Marko Pavlin, Boštjan Hudoklin, Marina Santo-Zarnik
Multichannel sensor bridge testing
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11. Drago Resnik, Barbara Malič, Uroš Aljančič, Danilo Vrtačnik, Matej Možek, Samo Penič, Silvo Drnovšek, Marija Kosec, Slavko Amon
Characterization of bondable Cr-Au metallization on PZT thin films
In: Proceedings, 43th International Conference on Microelectronics, Devices and Materials and the Workshop on Electronic Testing, September 12. - September 14. 2007, Bled, Slovenia, Janez Trontelj, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2007, pp. 127-132.
12. Marina Santo-Zarnik, Darko Belavič, Srečo Maček
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In: Proceedings, 43th International Conference on Microelectronics, Devices and Materials and the Workshop on Electronic Testing, September 12. - September 14. 2007, Bled, Slovenia, Janez Trontelj, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2007, pp. 189-194.
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Uniformity of properties of Ba_{0.3}Sr_{0.7}TiO₃ thin film planar capacitors made by a collective fabrication process
In: Proceedings, 43th International Conference on Microelectronics, Devices and Materials and the Workshop on Electronic Testing, September 12. - September 14. 2007, Bled, Slovenia, Janez Trontelj, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2007, pp. 133-138.

THESES

Ph. D. Thesis

1. Tadej Rojac: Mechanochemical Synthesis of NaNbO₃, (Prof. Marija Kosec)

B. Sc. Theses

1. Jana Faganeli: Automatic analysis of the microscopic pictures of the ceramic materials (Prof. Franjo Pernuš, Prof. Marija Kosec)
2. Sebastjan Glinšek: Processing and Characterization of K(Ta, Nb)O₃ Thin Films on Al₂O₃ Substrates (Prof. Stane Pejovnik, Asst. Prof. Barbara Malič)
3. Miha Skalar: Ferroelectrics layers PbMg_{1/3}Nb_{2/3}O₃-PbTiO₃ on alumina substrate (Prof. Marija Kosec)

PATENT APPLICATIONS

1. Martina Oberžan, Janez Holc, Marjan Buh, Vlasta Imperl
Processing of alumina porcelain for electrotechnics
No. P-200700138
Ljubljana, Urad RS za intelektualno lastnino, 2007.

INTERNATIONAL PROJECTS

1. Monolithic above IC Ultra High Value Capacitors for Mobile and Wireless Communication Systems
CAMELIA, 6. FP
NMP3-CT-2006-033103
EC; Clíodhna Horan, Tyndall National Institute, Lee Maltings, Cork; University College Cork, National University of Ireland, Cork, Ireland
Asst. Prof. Barbara Malič
2. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries
MULTICERAM, 6. FP
NMP3-CT-2006-032616
EC; Prof. Andrei Kholkin, University of Aveiro, Dept. of Ceramics & Glass Engineering, Aveiro, Portugal
Prof. Marija Kosec, Dr. Janez Holc, Prof. Robert Blinc, Prof. Raša Pirc
3. Multicomponent Oxides for Flexible and Transparent Electronics
MULTIFLEXIOXIDES, 6. FP
NMP3-CT-2006-032231
EC; Prof. Rodrigo Ferrao de Paiva Martins, UNINOVIA - Instituto de Desenvolvimento de Novas Tecnologias, Campus da FCT/UNL, Monte de Caparica, Portugal
Dr. Danjela Kuščer Hrovatin
4. REliable, Tuneable and INexpensive Antennas by collective fabrication processes
RETINA, 6. FP
AST4-CT-2005-516121
EC; Dr. Volker Ziegler, EADS Deutschland GmbH, Corporate Research Centre, Dept. LG-ME, München, Germany
Prof. Marija Kosec, Asst. Prof. Barbara Malič, Dr. Vid Bobnar
5. Inexpensive, high-perforMance, lead-free piezoelectric crystals and their applications in transducers for ultrasonic Medical DIagnostic and industrial Tools and Equipments
IMMEDIATE, 6. FP
COOP-CT-2005-017569
EC; Dr. Dragan Damjanovic, Ecole Polytechnique Federale de Lausanne, Swiss Federal Institute of Technology - EPFL, Ceramics Laboratory - LC, Materials Institute - IMX, Faculty of Engineering - STI, Lausanne, Switzerland
Prof. Marija Kosec, Dr. Andreja Benčan Golob
6. Multifunctional & Integrated Piezoelectric Devices
MIND, 6. FP
NMP3-CT-2005-515757
EC; Wanda Wolny, Ferroperm Piezoceramics A/S, Kvistgård, Denmark
Prof. Marija Kosec, Asst. Prof. Barbara Malič
7. Fuel Cell Application in a New Configured Aircraft
CELINA, 6. FP
AST4-CT-2005-516126
EC; Wolfgang Dressel, Airbus Deutschland GmbH, Hamburg, Germany
Prof. Marija Kosec, Dr. Danjela Kuščer Hrovatin
8. Removal of Hazardous Substances in Electronics: Processes and Techniques for SMEs
GREENROSE, 6. FP
COLL-CT-2004-500225
EC; Knut Aune, Abelia, Oslo, Norway
Prof. Marija Kosec
9. Miniaturised Ultrasonic, Engineered-Structures and LTCC-Based Devices for Acoustics, Fluidics, Optics and Robotics
MINUET, 6. FP
NMP2-CT-2004-505657
EC; Wanda W. Wolny, Ferroperm Piezoceramics A/S, Kvistgård, Denmark
Prof. Marija Kosec, Dr. Janez Holc
10. Polar Electroceramics
POLECER, 5. FP
G5RT-CT-2001-05024
EC; Wanda W. Wolny, Ferroperm Piezoceramics A/S, Kvistgård, Denmark
Prof. Marija Kosec, Asst. Prof. Barbara Malič

11. Electroceramics from Nanopowders produced by Innovative Methods
ELENA, COST 539
3311-06-837005
EC
Asst. Prof. Barbara Malič
12. Processing, Structure and Properties of Advanced Electronics Ceramics
BI-CN/07-09-005
Prof. Hong Wang, Xi'an Jiaotong University, Electronic Materials Research Laboratory,
Key Lab of the Ministry of Education Of China, Xi'an, China
Prof. Marija Kosec
13. Processing and Microstructure Control of Electronic Ceramics
BI-CN/05-07/001
Dr. Hong Wang, Electronic Materials Research Laboratory, Key Lab of Ministry of
Education of China, Xi'an Jiaotong University, Xi'an, China
Prof. Marija Kosec
3. Miniaturised Ceramic Low Pressure Sensors
Dr. Marina Santo Zarnik
4. Research and Development of Piezoelectric Micro-electromechanical Systems Based on
Pb(Zr,Ti)O₃ Thin Films on Si for Detection of Movement
Asst. Prof. Barbara Malič
5. Hybrid Micro Electromechanical Systems
Dr. Danjela Kuščer Hrovatin
6. Fuel cell systems as an auxiliary energy sources for autonomous military vehicles;
Auxiliary power supply based on fuel cells
Prof. Marija Kosec

RESEARCH PROGRAM

1. Electronic Ceramics, Nano-2D and 3D Structures
Prof. Marija Kosec

R & D GRANTS AND CONTRACTS

1. Materials and processes for shaping miniature thick film ceramic 2D and 3D structures
Dr. Marko Hrovat
2. Capacitive Ceramics: Pressure Sensors
Dr. Marko Hrovat

NEW CONTRACT

1. Project KeraPro – Ceramic Processor for Fuel Reforming and Cleaning of Obtained Gasses
Ministry of Defence
Dr. Marko Hrovat

VISITORS FROM ABROAD

1. Mr. Li Jin, EPFL-Swiss Federal Institute of Technology, Lausanne, Switzerland, January 8 – 26, 2007
2. Prof. Hong Wang, Prof. Wei Ren, Dr. Peng Shi, Huanfu Zhou, University Xi'an Jiaotong,
Xi'an, China, February 7 – 14, 2007
3. Prof. Vilho Lantto, University of Oulu, Oulu, Finland, March 15, 2007
4. Mr. Tomasz Jozenkow, Faculty of Microsystems Electronics and Photonics, Wroclaw,
Poland, July 9 – September 21, 2007
5. Ing. Viktor Lukac, Institute of Inorganic Chemistry, Rez, Czech Republic, August 20 – 25, 2007
6. Mr. Nico Gehrke, Hochschule Harz, Wernigerode, Germany, August 2 – October, 1, 2007
7. Ing. Jelena Bobić, Center of Multidisciplinary Studies, Belgrade, Serbia, September 10 – 28, 2007
8. Prof. Michael Karkut, Université de Picardie Jules Verne, Amiens, France, November 8 – 11, 2007
9. Prof. Klaus Reichmann, Institute for Chemistry and Technology of Inorganic Materials,
Graz University of Technology, Graz, Austria, December 7, 2007
10. Prof. Leszek Golonka, Politechnika Wroclawska, Wroclaw, Poland, December 12 – 15, 2007

Long Term Visitors

1. Laila Čakare Samardžija, B. Sc., Institute of Solid State Physics – ISSP, University of
Latvia, Riga, Latvia, July 31, 2000 – August 31, 2007
2. Elena Daniela Ion, M. Sc., National Institute for Materials Physics, Magurele, Romania,
March 18, 2004 – December 31, 2007
3. Dr. Tomoya Ohno, Kitami Institute of Technology, Department of Materials and Science,
Kitami, Hokkaido, Japan, April 15 – December 31, 2007

STAFF

Researchers

1. Dr. Andreja Benčan Golob
2. *Dr. John Gerard Fisher, left 1. 7. 2007*
3. Dr. Janez Holc
4. Dr. Marko Hrovat
5. **Prof. Marija Kosec, Head**
6. Dr. Danjela Kuščer Hrovatin
7. Asst. Prof. Barbara Malič
8. Dr. Marina Santo Zarnik***

Postdoctoral associates

9. Dr. Elena Chernyshova
10. Dr. Andrej Degen***
11. *Dr. Fabien Wilfried Remondiere, left 6. 8. 2007*
12. Dr. Jenny Julie Angeline Teller

13. Dr. Mišo Vukadinović***

Postgraduates

14. Sebastjan Glinšek, B. Sc.
15. Jerneja Godnjavec, B. Sc.
16. Tadej Rojac, B.Sc.
17. Gregor Trefalt, B. Sc.
18. Hana Uršič, B. Sc.

Technical officers

19. Darko Belavič***, B.Sc.
20. Jena Čilenšek, B.Sc.
21. Silvo Drnovšek, B.Sc.
22. Tina Ručigaj, B. Sc.
23. Miha Skalar, B. Sc.

Technical and administrative staff

24. Srečo Maček

*** Member of industrial or other organisation

ENGINEERING CERAMICS DEPARTMENT

K-6

The Engineering Ceramics Department is the leading group in the field of structural ceramics and ceramic technologies in Slovenia. The research programme comprises phenomena relevant to materials synthesis and component fabrication as well as mechanisms leading to the degradation of engineering ceramic structures under operating conditions. The applied research work is focused on new applications for engineering ceramics, the development of novel, high-strength, wear-, corrosion- and/or heat-resistant materials and the development of alternative, cost-effective and environmentally friendly ceramic technologies.



Head:
Prof. Tomaž Kosmač

In the area of low-pressure injection moulding (LPIM) we studied the rheological properties of paraffin suspensions of ceramic powders and we determined the parameters that influence these properties. It was found that in addition to the content of ceramic powder and its particle size distribution the rheological properties are significantly influenced by those material properties that can be expressed by the Hamaker constant. This constant may vary by an order of magnitude for different ceramic powders. We have also revealed that the threshold stress of a paraffin suspension may increase by as much as two or more orders of magnitude after cooling the dispersing medium below the solid-liquid transition temperature and subsequent heating above this temperature.

In addition, we worked on the shaping of piezoelectric resonators using the LPIM method. The aim of the project was to find the low limiting value of their size that still allows shaping by a single injection of a paraffin suspension containing ceramic powder into a metal mould. The shape of the resonators is complex since they are composed of at least 36 pillars at exact distances, with a minimum length-to-height ratio of 3. We have found that the minimum cross-section of the pillar that allows shaping is $500 \mu\text{m} \times 500 \mu\text{m}$, with the length-to-height ratio equal to 7. The basic problem during shaping is removing the sample from the mould without introducing any faults.

In 2007, as part of the research on the reactivity of AlN powder with water, we studied the influence of the hydrolysis temperature and the ageing time on the formation of crystalline products after the powder hydrolysis, i.e., bayerite, bohemite and pseudo-bohemite. The hydrolysis process for AlN was observed by measuring the suspension's pH, while the reaction products were characterized by XRD, SEM and TEM. The starting temperature (between the ambient temperature and 90°C) and the ageing time (between 10 minutes and 24 hours) strongly influence the reaction products and their morphology. The generalization of the model of Bowen et al. was suggested on the basis of these results.

Applicative research on composites made of carbon fibres was continued in 2007. We studied the preparation of C/C-SiC composites with a double matrix. The basic composite was made by the addition of polymeric precursors on the basis of phenol pitches with inter-mixed active and passive fillers. The composite surface was subsequently treated by polymeric precursors on the basis of polycarboxylanes that enable the preparation of a dense SiC surface layer. The composites prepared in this way are already used in the production of brake pads in the company MS Production, from Bled, Slovenia.

In the frame of the research on the wear of sintered metallic brake pads used in combination with ceramic braking discs on the basis of C/C-SiC composites we studied the morphology and phase composition of the layer formed on the surface of brake pads during braking. The high temperature during braking causes the partial oxidation of the metallic particles in the brake pad and the formation of the friction layer made of a mixture of metal oxides, which in turn influence the coefficient of friction as well as the wear of the pad.

In the area of new composites on the basis of the compound B_4C infiltrated with Al and in the frame of the applicative research project "Development of multi-functional B_4C -Al and B_4C -Mg composite materials for new products" we studied in cooperation with the department K9 and the private researcher V. Kevorkijan the possibilities of fabricating these materials without increased pressure, with the use of the reaction infiltration of melted metal into a ceramic preform. Our results revealed the possibility of the preparation of such composites and also their good mechanical properties, which indicates their potential use in anti-ballistic protection.

In 2007, research groups from the Engineering Ceramics Department, the Medical Faculty of the University of Ljubljana and the companies Interdent d.o.o. from Celje and Gald d.o.o. from Tolmin won the Puh award for inventions, development achievements and the use of research findings in introducing innovations for economic practice for a zirconia ceramic post for the aesthetic, fixed restoration of teeth.

In the area of bio-ceramics we investigated mostly the synthesis of bio-active coatings on the surface of ceramics based on Al_2O_3 and ZrO_2 . A biomimetic method of the precipitation of hydroxy-apatite (HA) from a super-saturated solution of calcium and phosphate ions was used. We studied in more detail the mechanisms of precipitation and growth of HA crystallites on ceramic substrates. Furthermore, we investigated the preparation of a bio-active ceramic material with satisfactory mechanical properties necessary for load-bearing bone substitutes. For this reason we coated the surface of Al_2O_3 and ZrO_2 ceramics with a thin, bio-active layer. Electron diffraction (SAED), energy-dispersive spectroscopy (EDS) and electron energy-loss spectroscopy (EELS) were used to prove the hydroxy-apatite (HA) crystal structure of the bioactive coating formed by the biomimetic method described above. The optimization of the preparation of a thin coating with a homogeneous thickness was controlled by varying the duration and temperature in the biomimetic method. We also investigated the influence of pH and the concentration of Ca^{2+} and PO_4^{3-} ions in the super-saturated solution on the coating. We found that the ionic product of HA in the solution has a major role in the coating formation. The ionic product controls whether or not the HA is crystallized on the surface, as well as whether the coating has a uniform thickness or is made of agglomerates instead.

In the frame of the applicative project "The influence of fillers on the mechanical properties of fibre-cement composites", we analyzed, in cooperation with the company ESAL d.o.o. from Anhovo, the mechanical properties of existing fibre-cement composites, using the usual methods for the characterization of mortars, concrete and fibre-cement composites. We made use of the expertise of researchers at the Institute of Building Construction. The mechanical tests were performed on standard testing samples of dimensions $40 \times 40 \times 160 \text{ mm}^3$. Next, we investigated the influence of the microstructure of the fibre-cement composites on their mechanical properties, especially the bending strength and the fracture toughness. Since the addition of amorphous silica to the starting mixture has a significant influence on these two mechanical quantities through the possibly changed microstructure we studied this influence. Amorphous silica reacts with $\text{Ca}(\text{OH})_2$ as a pozzolanic material during the cement maturing, thus its addition increases the composite's bending strength. However, it decreases the material toughness due to the density increase and the strengthening of the interface between the fibres and the cement matrix. Electron

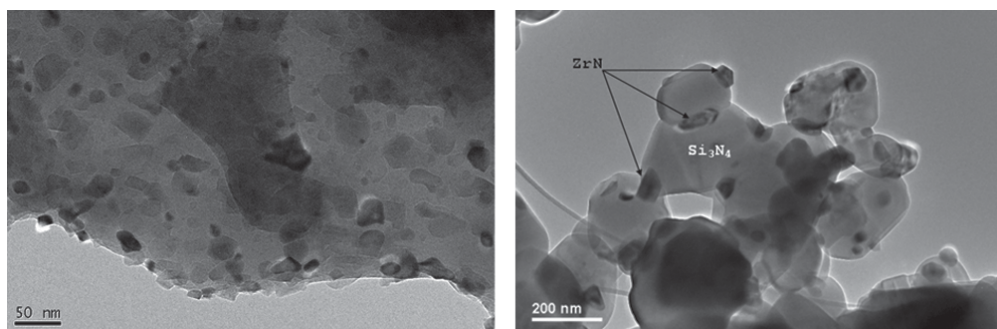


Figure 1: TEM pictures of the Si_3N_4 powder coated by TiN (a) or ZrN (b) nanoparticles.

microscopy was used to compare the structure of this interface with or without amorphous silica, and consequently its influence on the material strength and toughness. We found that the fracture of the composite is accompanied by both fibres' rupture and their partial pull-out from the cement matrix. In the second part of the investigations we studied the influence of the substitution of amorphous silica with meta-kaoline on the material's mechanical properties, such as the strength and toughness. We found that this substitution does not lead to a reduction of the mechanical properties, but in some cases the bending strength is even increased, which indicates the possibility of the substitution of amorphous silica with meta-kaoline in the serial production of fibre-cement composites.

In a cooperation with Esal d.o.o., we studied theoretically, in more detail, the Weibull statistics of the mechanical properties of (quasi)brittle construction materials for civil engineering. Repeated measurements of several mechanical quantities, such as the bending strength and fracture toughness, can be well described by 2-parametric Weibull statistics. Experimental data from the mechanical tests on Esal corrugated roofing sheets from fibre-cement were used as the basis for Monte Carlo simulations of the Weibull statistics. The significance of this study is the estimation of the degree of reliability in predicting the statistical distribution of the mechanical properties of a large number of roofing sheets on the basis of a relatively small number of measurements on testing sheets.

Investigations of dental ceramics based on tetragonal ZrO_2 (Y-TZP) continued in some different directions in 2007. Within a PhD dissertation at the Medical Faculty in Ljubljana (MF) we studied the influence of the surface treatment on the kinetics of the accelerated ageing of Y-TZP ceramics in an aqueous medium, as well as the fatigue in artificial saliva. The results indicated that untreated samples are subjected to ageing (i.e., the low-temperature t - m transformation in hydro-thermal conditions) the most, while the sand-blasted and ground surfaces are more resistant. The greater resistance of the mechanically treated Y-TZP ceramics against ageing is attributed to twinning

and partial deformation of the crystal lattice of the retransformed tetragonal grains, accompanied by the presence of surface compressive stress. The life-time ability during mechanical fatigue in artificial saliva is significantly decreased in comparison to the fatigue in air, indicating a strong influence of stress corrosion, which is additionally influenced by mechanical failures due to grinding and sand-blasting. In addition to clinical testing the prototype dental posts which we developed in cooperation with dentists from MF, we focused on the adhesion of dental cements on the surface of sintered Y-TZP ceramics as the supporting material for full-ceramic dental restorations. The adhesion on a smooth surface is inadequate because of the chemical inertness of Y-TZP, while it is somewhat better on the sand-blasted surface and still better on the surface coated by a thin adhesive layer of aluminium oxide with a large specific surface. This layer was synthesized by the precipitation and recrystallization of aluminium hydroxide, formed by the hydrolysis of AlN powder in an aqueous suspension and subsequent thermal treatment. The coating procedure is simple and repeatable, and we took out a patent for this procedure. Systematic measurements of the shear strength of the interface of normal dental cements on the surface of supporting ceramics, which are performed in cooperation with MF, reveal that it is possible to achieve even five times larger values compared to Y-TZP ceramics without coating.

In the frame of our long-standing cooperation with Hidria AET d.o.o. from Tolmin, Slovenia, we continued and completed the development of new ceramics with a high alumina content (mass fraction of 96%) with improved wear resistance, where the mixture of manganese and titanium oxides was used as the secondary phase. Owing to the formation of the transient liquid phase with a low melting point the sintering of such a composite ceramic material takes place at 300°C to 400°C lower temperatures, compared to those for "standard" ceramics with a high alumina content and the addition of silicates. We determined the optimal composition of the liquid phase and the appropriate sintering conditions to get a fine-grained microstructure and consequently improved the mechanical properties and the wear resistance of sintered ceramics. The wear resistance of Al₂O₃ ceramics was measured on samples of different shapes (pellets and hollow cylinders) by applying abrasive tests (polishing and grinding) on a standard machine for polishing the samples and measuring the mass of the samples for repeatable test conditions.

With regard to the development of a ceramic glow plug in cooperation with the companies AET d.o.o. and Iskra ISD from Kranj we studied the preparation of dense β -SiAlON/TiN and β -SiAlON/ZrN electrically conducting ceramic composites by reaction sintering of the Si₃N₄ powder coated by TiO₂ or ZrO₂ nanoparticles. The oxide coating on Si₃N₄ was prepared by the sol-gel method with the use of tetra-butyl titanate (TiO₂ coating) or by homogeneous precipitation of ZrO₂ from a solution of zirconium acetate and urea (ZrO₂ coating). By using these procedures we tried to achieve a distribution of conducting nanoparticles around large grains of SiAlON, in order to obtain higher electrical conductivity with a small amount of conducting phase, retaining good mechanical properties of the matrix. We found that for both methods mentioned above, TiO₂ and ZrO₂ react with silicon nitride to form TiN and ZrN, respectively, during the reaction sintering or heat treatment, and these findings were confirmed by X-ray analysis and transmission electron microscopy (Fig. 1).

Some outstanding publications in the past three years

1. Tomaž Kosmač, Aleš Dakskobler, Čedomir Oblak, Peter Jevnikar. The strength and hydrothermal stability of Y-TZP ceramics for dental applications. *International journal of applied ceramic technology*, 2007, vol. 4, p. 164–174.
2. Kristoffer Krnel, Zmago Stadler, Tomaž Kosmač. Preparation and properties of C/C-SiC nano-composites. *J. Eur. Ceram. Soc.*, 2007, vol. 27, p. 1211–1216.
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U3-MM/K6-06-028
Dr. Jae-Ho Jeon, Korea Institute of Machinery and Materials (KIMM), Ceramic Materials Group, Changwon, Korea
Prof. Tomaž Kosmač, Asst. Prof. Miran Čeh
2. Design and Development of Functionally Graded SiAlON Ceramics
BI-TR/04-07-007
Prof. Hasan Mandal, Anadolu University, Faculty of Engineering and Architecture, Department of Materials and Engineering, Eskisehir, Turkey
Prof. Tomaž Kosmač

R & D GRANTS AND CONTRACTS

1. Research of C/C-SiC ceramic matrix composites for braking systems
Dr. Kristoffer Krnel
2. Influence of the fillers on mechanical properties of fibre-cement composites
Dr. Kristoffer Krnel
3. Development of multifunctional B4C-Al and B4CMg composite materials for new products
Prof. Tomaž Kosmač

RESEARCH PROGRAM

1. Engineering and bio-ceramics
Prof. Tomaž Kosmač

NEW CONTRACTS

1. Co-financing of the project »Influence of the fillers on mechanical properties of fibre-cement composites«
ESAL, d.o.o. Anhovo
Dr. Krnel Kristoffer
2. Research & development work in the frame of the project »CarCIM«
HIDRIA AET, d.o.o., Tolmin
Prof. Kosmač Tomaž

VISITORS FROM ABROAD

1. Dr. Maja Dutour, Sikirić, Institute Ruder Bošković, Zagreb, Croatia, Jan. 15, 2007
2. Dr. Jae-Ho Jeon, Ceramic Materials Team, Korea Institute of Machinery and Materials, Sangnam-Dong, Chwangwon, Korea, March, 28 - 30, 2007
3. Dr. Stephen Ackers, Eternit, Zürich, Switzerland, June 5, 2007

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6. Ayse Kalemata, Nurcan Calis-Acikbas, Anadolu University, Faculty of Engineering and Architecture, Department of Materials Science and Engineering, Eskişehir, Turkey, Dec. 9 - 23, 2007

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DEPARTMENT FOR NANOSTRUCTURED MATERIALS K-7

The basic and applied research in the Department for Nanostructured Materials includes ceramic materials, intermetallic alloys and minerals. Our research encompasses conventional processing as well as the development of new technologies and methods for preparing new materials with novel properties. It includes experimental and theoretical investigations of structures, analyses of chemical compositions at the atomic level, and measurements and calculations of physical properties, all of which help us to improve the properties of micro- and nanostructured materials.



Head:
Prof. Spomenka Kobe

In the frame of a European Network of Excellence we continued our research on **quasicrystals** as promising **materials for hydrogen storage**. We focused on two compositions: $Ti_{40}Zr_{40}Ni_{20}$ and $Ti_{45}Zr_{35}Ni_{17}Cu_3$. With a systematic experimental approach we established the optimal conditions for the processing of ribbons by melt-spinning and the methods for their characterizations. In accordance with the literature data we showed that copper accelerates quasicrystalline i-phase formation, but it inhibits hydrogen uptake. Ribbons were crushed in a protective argon atmosphere in order to increase the amount of clean surface for hydrogen-molecule dissociation, and we hydrided the samples under a hydrogen pressure of 40 bar and temperatures between 200 and 300°C. From the XRD peak shift after absorption we were able to calculate the expansion of the quasilattice and the content of hydrogen using literature data. We also observed a drop of magnetization with hydrogen content, which was measured by means of mass spectrometry of the desorbing hydrogen. The obtained powders were examined by HRTEM and the i-phase was observed and determined. The results were included in a publication that was accepted by the Journal of Alloys and Compounds; they were also presented to the international and domestic scientific communities.

We continued with our research on **magnetocaloric materials**, which are important for **magnetic refrigeration**, an ecological technology. Research focussed on the $Gd_5Si_2Ge_2$ and $Gd_5Ge_2(Fe_xSi_{1-x})_2$ systems. The $Gd_5Si_2Ge_2$ samples were prepared by two methods: with an arc-melter and a melt-spinner. With the arc-melter we observed how the cooling rate affects the macro- and microstructure of the samples. These materials show complex surface macrostructure features, which vary from a sinew-like structure at very fast cooling rates through to an almost Fullerene-like structure at slower cooling rates. Transmission electron microscopy (TEM) showed numerous twins in the sample. With a melt spinner we produced ribbons of different shapes, depending on the wheel speed the structure changed from amorphous to crystalline. With TEM we observed a larger number of twins than in the samples made with arc melting. The results were presented at the 2nd International Conference of the IIR on Magnetic Refrigeration at Room Temperature, THERMAG 2007. Samples from the $Gd_5Ge_2(Fe_xSi_{1-x})_2$ system were only arc melted. With the addition of Fe the Fullerene-like macrostructure slowly disappeared and conventional ingots with smooth surfaces resulted. Iron also reduced the Curie temperature and encouraged the formation of the $Gd_5(SiGe)_3$ phase at the expense of the magnetocaloric $Gd_5(SiGe)_4$ phase. We observed a reduction of the hysteresis losses, which was the purpose of the Fe addition, because high hysteresis losses have a negative effect on the cooling capacity during magnetic refrigeration. We also investigated technologically interesting materials by means of calculations within the framework of the density-functional theory. These studies were focussed on magnetocaloric materials and on the properties of complex metallic alloys.

In the field of **magnetic thin films** we continued with our research on Sm-Fe-Ta films processed by pulsed-laser deposition and on films based on CoPt produced by a chemical method. Both materials have the potential for MEMS applications. CoPt has a very strong perpendicular magnetocrystalline anisotropy and excellent resistance to oxidation and corrosion. The $Co_{0.5}Pt_{0.5}$ is related to the presence of the ordered L10 phase. This is a natural multilayer, which consists of alternating pure Co and pure Pt (001) planes. The strong crystallographic anisotropy is associated with a strong magnetic anisotropy due to the strong magnetic spin-tir coupling on the Pt and the strong

A test series of ceramic ball-heads for hip-joints with a gradient composition, produced in the frame of the European project “Biograd”, were tested. The results confirmed that the new grade of functionally graded ceramic hip-joints allows a higher load than the commercially available alumina. Cordis published an offer for the new industrial technology on the web.

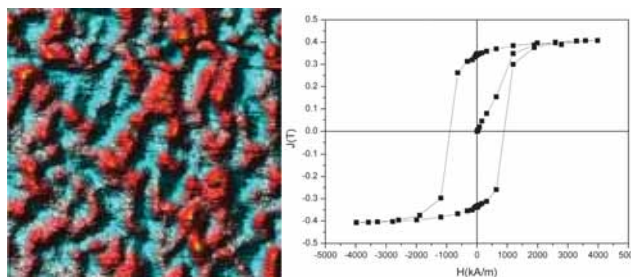


Figure 1: MFM image and hysteresis loop of a thermally treated thin layer of CoPt-700°C/1h/Ar+H2 for MEMS application.

hybridization between the Pt 5d and the Co 3d states. The CoPt thin films (20-600 nm) were synthesized using the electrodeposition method and characterized with a SQUID magnetometer and with AFM/MFM. The as-deposited films are cubic and nanocrystalline with grain sizes between 10 and 80 nm. The magnetization lies in the plane, and therefore the coercivity is low. An MFM image shows that interaction domains are present in the material. On the other hand, the annealed film which contains the L10 phase has a coercivity of $\mu_0 H_c = 1.2\text{T}$ and displays interconnected stripe domains corresponding to the up and down orientations of the magnetization.

In ZnO ceramics doped with very small amounts of Sb_2O_3 (< 0.017 mol.%) the kinetics of the grain growth under the influence of inversion boundaries (IBs) was explained. An equilibrium layer, with about the same amount of Sb as that at the IB, is formed at the grain boundaries of Sb-doped ZnO. The concentration of the Sb at the grain boundaries can be expressed with the equation: $C_m(\text{Sb}) = 3C_{\text{IB}}(\text{Sb}) = 0.300/\text{G}$. At additions of Sb below the amount required for the formation of an equilibrium layer, Sb triggers the formation of IBs in a reduced number of ZnO grains, depending on the amount – a lower number for smaller, and a higher number for larger additions of Sb. Under such conditions either coarse- or fine-grained ZnO ceramics can be developed. As long as grains with IBs can grow at the expense of normal grains the kinetic grain-growth exponent n is 2, which indicates that grain growth is indeed dictated by the growth of a thermodynamically stable two-dimensional structure of IBs. The longer is the period of grain growth, the larger the ZnO grains can grow. Once the ZnO grains with IBs prevail in the



Figure 2: Test series of ceramic ball-heads for hip joints with a gradient composition were produced in the frame of the European project "Biograd". (http://cordis.europa.eu/fetch?CALLER=OFFPR_TM_EN&ACTION=DEDOC=2&CAT=OFFRE&QUERY=1197645527573&RCN=3420)

microstructure, the grain growth is slowed and the grain-growth exponent n increases to 4. For additions of Sb above the amount required for the formation of an equilibrium layer, Sb triggers the formation of IBs in most of the ZnO grains, which results in fine-grained ZnO ceramics. The strong inhibition of the grain growth in this case is also indicated by the grain-growth exponent n being above 10. Based on the investigations of ZnO ceramics doped with very small amounts of Bi_2O_3 and Sb_2O_3 , the main parameters that influence grain growth and microstructure development in the basic system of varistor ceramics under the influence of inversion boundaries (IBs) were recognised. The obtained fundamental knowledge enabled us to be the first to succeed in the preparation of Bi_2O_3 - and Sb_2O_3 -doped ZnO ceramics with an average grain size several times larger than in pure ZnO under the same sintering conditions, which was, in general, considered to be impossible. Guided by a fundamental knowledge of the microstructure development under the influence of inversion boundaries (IBs) we continued with research activities on low-doped varistor ceramics. Based on a systematic analysis of the influence of very small amounts of Al_2O_3 (< 0.12 mol.%) on the microstructural and electrical characteristics we proposed a mechanism which, in such a complex system of varistor

ceramics, explained the inhibition of the grain growth by the small amounts of Al_2O_3 in the Bi_2O_3 -rich liquid phase and the influence of Al_2O_3 on the nature of the grain boundaries. Also, alternative approaches to the preparation of varistor ceramics via the direct mixing of pre-reacted varistor phases and by mechano-chemical activation of the starting powder with intensive milling was studied. Several formulations with 2 to 3 times smaller amounts of dopants added to the ZnO in comparison to the standard compositions were developed. They enabled the preparation of varistor ceramics with characteristic breakdown voltages in the range 80–240V/mm. Some of these compositions are already being tested at our industrial partner for **industrial processing and applications in various types of varistors**.

Grain-growth studies of zinc oxide ceramics have indicated that inversion boundaries (IBs) are the growth faults that control the growth of the ZnO grains. To substantiate this observation we designed experiments to study the nucleation of IBs. Low-temperature experiments showed that in the ZnO- SnO_2 system IBs form before the Zn_2SnO_4 spinel phase and grains with IBs grow exaggeratedly at the expense of the normal ZnO grains until they completely dominate the microstructure. Experiments using ZnO single crystals embedded into ZnO powder with the addition of SnO_2 , Sb_2O_3 and In_2O_3 showed that, depending on the oxidation state of the IB-forming dopant ions, there are two competing mechanisms of IB nucleation: (i) internal diffusion, and (ii) surface nucleation and growth. The first mechanism is typical for III+ dopants and is controlled by Zn-vacancy diffusion, whereas the second mechanism holds for all IB-forming dopants and is controlled by the chemisorption of the dopants on Zn-deficient (0001) surfaces. In both cases the driving force for the inversion is the preservation of the local charge balance. We also started with the research activities on the synthesis of **ZnO nanostructures** using the solid-vapour phase thermal sublimation method. ZnO-based nanostructures could find applications in optoelectronics, sensors, transducers and biochemical science because ZnO is bio-safe. Preliminary studies were focused on the influence of processing on the morphology of ZnO nanostructures obtained on various substrates with the aim to define the

conditions for the reproducible preparation of the desired ZnO nanostructure. The formation and the structure of nanosized ZnO particles were studied using electron microscopy techniques. Nucleation, self-assembly and the morphology of very interesting features, like tetrapods, wires, needles, twinned crystals, were examined.

In the frame of European project "Meddelcoat" we are involved in **an improvement to the ingrowths of the metal part of the prosthesis into bone**. In order to protect the metallic stem from corrosion, to prevent the leaching and diffusion of metal ions into the body and to improve the adhesion of the bioactive coatings, we investigated the in-situ hydrothermal synthesis of a thin layer of TiO_2 at the surface of the alloy. We successfully synthesized a 100-nm-thick anatase layer. Anatase is the most bioactive form among the different allotropic modifications of TiO_2 . The idea of the project is to coat the metal stem with a thin layer of bioglass, which is said to accelerate the integration of the implant with the surrounding tissue. Since it was not possible to obtain bioglass of high purity with small enough particles we introduced a sol-gel synthesis. In contrast to the conventional procedure involving milling we obtained powder with sub-micrometer sized particles. The bioglass coating on the surface of the alloy was made by means of **electrophoretic deposition** from the suspension of the powder or electrodeposition in the sol. The second part of the research in the frame of the Meddelcoat project is focused on the **production of porous scaffolds** with an improved capability for bone ingrowth. Firstly, we have looked to learn from Nature and would like to mimic it in the future. As an example of a natural hard tissue with superior mechanical properties we have investigated a tooth composition and structure on the micro and nano levels. It is known that tooth is composed of elongated and oriented crystals of calcium phosphates (among which is hydroxyapatite) and that this specially organized structure is the basis for its extraordinary mechanical strength and resistance to cracks. In the future we will concentrate on the synthesis of anisotropic hydroxyapatite crystals and the preparation of porous scaffolds with better properties than those that are commercially available.

A lot of attention was paid to research on electrophoretic deposition, which was used for the preparation of thin and thick deposits on various metal substrates. We used aqueous and non-aqueous suspensions of oxide and non-oxide particles of nanometre size. We have ascertained that the method enables the preparation of green deposits with great homogeneity, but for the preparation of dense deposits with low shrinkage during sintering, besides de-agglomeration, the suitable addition of a surface-active agent plays a key role. Special attention was focussed on the properties of SiC powder and on the applicability of electrophoretic deposition for the infiltration of the fabric made from SiC fibres. We have investigated the **electrokinetic properties** of the powder in water-based suspensions across the whole pH range and hence enabled tailoring of the suspension's properties to the properties of the fibre fabric. The results of the infiltration of the SiC powder are used in the development of a **SiC/SiC composite for use in a future fusion reactor**. These studies have been going on for four years within the framework of the European fusion program. Besides the development of a suitable technique for the preparation of a continuous-fibre reinforced ceramic composite and the deposition of suitable coating onto fibres, a lot of effort was made to densify the ceramic matrix below a temperature of 1500°C . In cooperation with the F8 department we have verified the suitability of some potential sintering additives (regarding the expected activation after irradiation), and at the end of the year the selected sintered samples were irradiated. The results are promising; the activation of the sintered samples is considerably lower than the activation of Eurofer steel, which will be used in the experimental ITER reactor. In the field of fusion-related materials we continued to study the interfaces between the SiC fibres and the SiC-based matrix material. This interface enhances the mechanical properties of the composite material. Using physical vapour deposition various materials were used as the interface (WC, CrC, DLC, etc.), and the adhesion and microstructure were studied.

In cooperation with other groups from Slovenia and other countries in Europe we studied the microstructure, nucleation and crystallisation of different materials as a function of preparation conditions. We continued with our research on **germanium quantum-dots** embedded in an amorphous SiO_2 matrix. Ge was prepared using the ion-implantation technique and heat treated at different temperatures. In certain conditions the self-assembly of the particles took place. Using high-resolution electron microscopy and Z-contrast microscopy we studied the formation of the self-assembled systems.

A member of the department, Katja Rade, was presented with the Prešeren award for her diploma work, which was performed at the Faculty of Chemistry and Chemical Engineering.

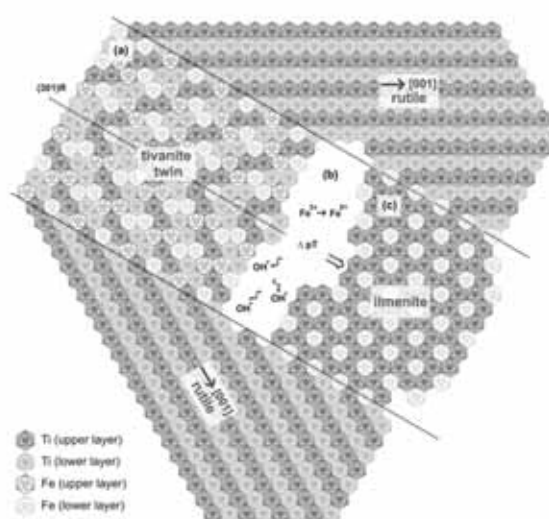


Figure 3: Schematic representation of an intrinsically twinned tivanite platelet and epitaxial nucleation of rutile crystals in the (301) twinned orientation. Dehydration of the tivanite platelet, resulting in the nucleation of ilmenite lamella with the corundum structure.

We started with the investigations of **nanosized particles used for catalytic applications**. Materials such as TiO_2 , CeO_2 , and Ce-Cu-O were prepared by “wet” routes and were studied by analytical electron microscopy. The influence of preparation conditions on morphology, size, crystallinity and crystal defects was examined. Preliminary results were presented at an international conference and will be published.

In the area of the development and implementation of atomically resolved **HAADF-STEM microscopy** we showed, using the model materials CaTiO_3 , SrO-SrTiO_3 and $\text{Na}_2\text{NaNb}_5\text{O}_{10}$, that the local lattice distortions significantly influence the experimentally determined intensities of single-atom columns. Furthermore, we showed that realistic values of the Debye-Waller factor for atoms comprising the investigated structure (interface, planar fault, etc.) are needed for an exact quantitative interpretation of the experimental HAADF-STEM intensities. Only then can the intensities of the atom columns in the simulated images correspond to the true values and can they be successfully compared with the intensities in simulated images. For the $\text{Pb}(\text{Mg,Nb})\text{O}_3\text{-PbTiO}_3$ (PMN-PT) material we implemented a mechanical polishing technique for the preparation of thin foil specimens for TEM observations (the tripod method). A comparison of the results on the chemical composition of thin foils prepared by ion-milling and mechanical polishing (tripod) showed that only the specimens prepared by the tripod method are suitable for a chemical analysis using EDXS. This is because ion-milling causes extensive damage to the thin foil and changes the chemical composition in the damaged region due to Pb evaporation. It was concluded that any analytical results

performed using EDXS on materials containing Pb may be questionable if ion-milling is used for the sample preparation.

We continued with the synthesis and characterization of **nanorods with the perovskite structure** ATiO_3 ($\text{A}=\text{Ba,Sr,Ca}$) with the electrophoresis (electrodeposition) of sols into ordered arrays of nano-sized channels of anodic alumina and into pores in polycarbonate membranes. By using TEM and electron diffraction analysis we found that these nanorods are dense and polycrystalline, with the grain size ranging between 25 and 50 nm. The length of the nanorods is approximately 10 μm , with the diameter of an individual nanorod being in the range 100–180 nm.

One of the important accomplishments in the past year was the **publication of a scientific monograph** entitled “Mineral localities of Slovenia”. On the 384 pages all the major Slovenian mineral localities are described: the book starts with a historical background, before providing a geographical description, and a description of the geology and information about the formation of the minerals. In addition to mineral paragenesis the descriptions include a complete geological background necessary to understand the individual mineral occurrences. The special value of this approach is that each of the described localities is placed into a specific tectonic setting related to individual orogene phases on the territory of Slovenia. The monograph will be of a great educational value as supplementary material for university studies, while the synthesis of the knowledge from various scientific disciplines in this book will be valuable to a wide professional community from the fields of geology, ore exploration,

mineralogy, solid-state chemistry and Nature preservation.

The structure and chemistry of (111) **twins in MgAl_2O_4 spinel crystals** from Pinpyit near Mogok (Myanmar, formerly Burma) were studied using methods of transmission electron microscopy (TEM). Crystallographically, (111) twins of spinel can be described by a 180° rotation of the oxygen sublattice normal to the twin composition plane. This operation generates a local *hcp* stacking in an otherwise *ccp* lattice and maintains a regular sequence of kagome and mixed layers. In addition to rotation, no other translations are present in the (111) twins in these spinel crystals. Quantitative analyses of the HRTEM (phase contrast) and the HAADF-STEM (Z-contrast) images of the (111) twin boundary have confirmed that Mg^{2+} ions are replaced with Be^{2+} ions in the boundary tetrahedral sites. The Be-rich twin-boundary structure is closely related to the BeAl_2O_4 (chrysoberyl) and $\text{BeMg}_3\text{Al}_8\text{O}_{16}$ (taaffeite) groups of intermediate polysomatic minerals. The formation of (111) twins is a preparatory stage of polytype/polysonic (taaffeite) formation and is a result of the thermodynamically favourable formation of *hcp* stacking due to Be incorporation on the {111} planes of the spinel structure in the nucleation stage of crystal growth. Twinned crystals of rutile (TiO_2) from Diamantina in Brazil were investigated using analytical transmission electron microscopy methods. A high-resolution transmission electron microscopy (HRTEM) imaging of the (301) twinned rutile revealed the existence of a coherent interlayer at the twin boundary. The interphase lamella with a lateral width of a few nanometres consists of ilmenite (FeTiO_3) containing some Al. The orientation relationship between the ilmenite lamella and the epitaxial rutile crystals is $(011\text{-}0)[0001]_i \parallel (301)[010]_r$. The lattice mismatch between

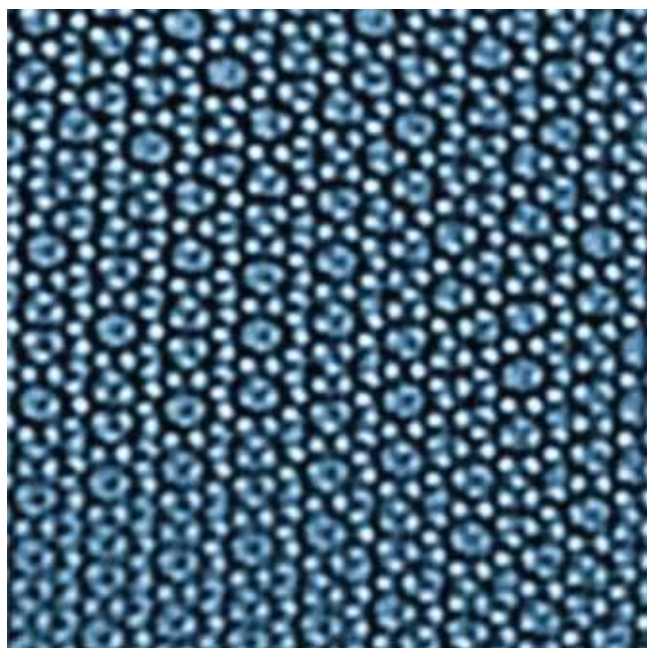


Figure 4: Icosahedral phase of a quasicrystal of $\text{Ti}_{40}\text{Zr}_{40}\text{Ni}_{20}$ observed by HRTEM (Fourier filtering of the HRTEM image using Digital Micrograph software)

the ilmenite and the rutile appears to be compensated by the incorporation of Al into the ilmenite. The presence of goethite-related reflections and the existence of nanotwins in the ilmenite lamella imply that it formed via a thermally induced dehydration process from an oxyhydroxide precursor mineral with a tivanite-type structure. This lamella subsequently served as a nucleation site for the epitaxial growth of rutile domains in a (301) twin configuration.

For industry we studied the structure and chemical composition of nanometre-sized layers based on Al_2O_3 - SiO_2 and TiO_2 pigments. The results of the work over the past few years were collected in the final report of the Centre of Excellence: Nanosciences and Nanomaterials. For various customers a determination of the asbestos fibres in air, water and soils was performed using analytical electron microscopy.

We also carried out analyses in the field of electron-probe microanalysis (SEM, EDXS, WDXS) for several industrial partners: DONIT-TESTIT, Medvode; COMET, Zreče; LEK, Ljubljana; TE-TOL, Ljubljana; EMO-FRITE, Celje; LE-TEHNIKA, Kranj; and ISKRAEMECO, Kranj.

Members of the department are heavily involved in managing the **Center for Electron Microscopy** within the frame of the national infrastructure Center for Microstructural and Surface Analysis. The implementation of various electron microscopy analytical techniques and the possibility for researchers to access a research infrastructure for electron microscopy is of utmost importance for numerous research institutions, industrial partners as well as for graduate and post-graduate education.

One of the most important accomplishments in the past year was the publication of a scientific monograph entitled “Mineral localities of Slovenia”. On the 384 pages all the major Slovenian mineral localities are described: starting with a historical background, the book provides a geographical description, presents the geology and describes the formation of the minerals.

Some outstanding publications in 2007

1. Aleksander Rečnik, Nina Daneu, Slavko Bernik. Nucleation and growth of basal-plane inversion boundaries in ZnO. *J. Eur. Ceram. Soc.*, 2007, vol. 27, no. 4, pp. 1999–2008.
2. Slavko Bernik, Nina Daneu. Characteristics of ZnO-based varistor ceramics doped with Al_2O_3 . *J. Eur. Ceram. Soc.*, 2007, vol. 27, str. 3161–3170.
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5. C. Kostoglou, Matej Komelj, Manfred Fähnle. Theory of x-ray absorption spectroscopy in solids : mixing of the core states by the aspherical effective potential. *Phys. rev., B, Condens. matter mater. phys.*, 2007, vol. 75, no. 21, pp. 214426-1–214426-5.

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1. Saša Novak, Katja König, Stojana Veskovič Bukudur, A method for hydrophobisation of a ceramic powder by applying an organic coating in an aqueous suspension: Patent No. 22211, Ljubljana, Slovenian Intellectual Property Office, Ljubljana, Slovenia, 2007.

Awards and appointments

1. Nataša Drnovšek: “A double-layer coating on a $\text{Ti}_6\text{Al}_4\text{V}$ alloy for biomedical applications”. Winning contribution of young scientists at the 15th Conference on Materials and Technologies in the field “Anorganic Materials”, Portorož, October 8–10, 2007.
2. Katarina Rade: “Study of polymethacrylic acid in presence of various cations in aqueous media”. Winning contribution of young scientists at the 15th Conference on Materials and Technologies in the field “Nanomaterials and Nanotechnologies”, Portorož, October 8–10, 2007.
3. Kristina Žagar: “Synthesis and characterization of perovskite nanorods”. Winning contribution of young scientists at the 15th Conference on Materials and Technologies in the field “Nanomaterials and Nanotechnologies”, Portorož, October 8–10, 2007.
4. Katarina Rade: “Effect of valency of counterion on behaviour of two stereoisomers of polymethacrylic acid in aqueous solutions”. Prešeren Prize of the Faculty of Chemistry and Chemical Technology, University of Ljubljana for the best B.Sc. thesis in 2007 (mentor: Prof. Ksenija Kogej); 7 December 2007

Organization of conferences, congresses and meetings

1. SLONANO2007, Ljubljana, 10–12 October 2007
2. 15th Conference on Materials and Technology, Portorož, 8–10 October 2007 (co-organisation)
3. European School in Materials Science: Properties and Application of Complex Metallic Alloys, Ljubljana, 21–26 May 2007 (co-organisation)
4. 8 Multinational Congress on Microscopy (8MCM), Prague, Czech Republic, June 17–21 (members of International Advisory Board)

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 17. Aleksander Rečnik, Nina Daneu, Janez Zavašnik, Tadej Dolenc
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Minerali v karbonskih skrivilavih glinavcih med Trojanami in Ljubljano
In: Nahajališča mineralov v Sloveniji, Aleksander Rečnik, ed., Ljubljana, Institut Jožef Stefan, Odsek za nanostrukturne materiale, 2007, pp. 151-167.
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 21. Aleksander Rečnik, Željko Habl
Nahajališča kremenovih kristalov na Hrastniku pri Škofji Loki
In: Nahajališča mineralov v Sloveniji, Aleksander Rečnik, ed., Ljubljana, Institut Jožef Stefan, Odsek za nanostrukturne materiale, 2007, pp. 76-87.
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Granati iz skarnov na Kopah na Pohorju
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29. Aleksander Rečnik, Janez Zavašnik
Biterminirani kristali kremenja iz okolice Turjaka. I., Osolniška preloman cona
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30. Aleksander Rečnik, Janez Zavašnik
Biterminirani kristali kremenja iz okolice Turjaka. II., Medvediška prelomna cona
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31. Goran Velikonja, Aleksander Rečnik
Kristali kremenja iz permskih peščenjakov pri Sovodnju
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32. Renato Vidrih, Aleksander Rečnik
Nahajališče pirita v Dolžanovi soteski nad Tržičem
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33. Saša Zavadvaj, Janez Zavašnik, Aleksander Rečnik, Vladimir Bermanec, Tadej Dolence
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In: Nahajališča mineralov v Sloveniji, Aleksander Rečnik, ed., Ljubljana, Institut Jožef Stefan, Odsek za nanostrukturne materiale, 2007, pp. 115-120.
5. Benjamin Podmiljšak, Paul J. McGuinness, Irena Škulj, Boštjan Markoli, Goran Dražič, Spomenka Kobe
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6. Zoran Samardžija, Miran Čeh, Jae-ho Jeon
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7. Christina Scheu, L. M. Cha, Sašo Šturm, Harald F. Chladil, Paul H. Mayrhofer, Helmut Clemens, Walter Wolf, Raimund Podloucky
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8. Sašo Šturm, Boštjan Jančar, Ines Bračko
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9. Tea Toplišek, Goran Dražič, Saša Novak, Spomenka Kobe
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11. Kristina Žagar, Sašo Šturm, Miran Čeh
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Invited Paper

1. Miran Čeh, Sašo Šturm, Makoto Shiojiri
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Regular Papers

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2. Nina Daneu, Aleksander Rečnik, Herbert Schmid, Werner Mader
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3. Medeja Gec, Vesna Šrot, Jae-ho Jeon, P. A. Aken, Miran Čeh
Comparison of chemical composition of PMN-PT thin foils prepared by ion-milling and wedge preparation technique
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4. Boštjan Markoli, Paul J. McGuinness, Benjamin Podmiljšak, Irena Škulj, Spomenka Kobe
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THESES

Ph. D. Thesis

1. Zoran Samardžija
Electron probe microanalysis of doped perovskite ceramics
(Asst. Prof. Miran Čeh, Prof. Anton Zalar)

B. Sc. Theses

1. Simona Ovtar
Evaluation of amorphous phase in SiC-based samples by X-ray diffraction
(Asst. Prof. Saša Novak Krmpotič, Prof. Anton Meden)
2. Mitja Škalič
Synthesis and characterization of $BaTiO_3$ nanorods
(Asst. Prof. Miran Čeh, Asst. Prof. Boštjan Markoli)

PATENT APPLICATIONS

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INTERNATIONAL PROJECTS

1. Development of Functional Material for Insulating Flow Channel Inserts (Ceramic Processing of SiC Composites for Functional Applications) - UT1-FU
EURATOM - MHEST, 7. FP, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Saša Novak Krmpotič, Asst. Prof. Goran Dražič
2. Development of Composites with Advanced/Alternative Manufacturing Concepts: Vacuum Slip Infiltration of SiC/SiC - UT2-FU
EURATOM - MHEST, 7. FP, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083

- EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Goran Dražič, Asst. Prof. Saša Novak Krmpotič
3. Research Unit - Administration and Services - RU-FU
EURATOM - MHEST, 7. FP, Slovenian Fusion Association - SFA
Annex No. 2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Saša Novak Krmpotič, Prof. Milan Čerček
 4. Multifunctional Bioresorbable Biocompatible Coatings with Biofilm Inhibition and Optimal Implant Fixation
6. FP, MEDDELCOAT, NMP3-CT-2006-026501
EC; Prof. Jozef Vleugels, Katholieke Universiteit Leuven, Research & Development, Leuven, Belgium
Asst. Prof. Saša Novak Krmpotič

5. Enabling Science and Technology through European Electron Microscopy ESTEEM, 6. FP, 026019
EC; Prof. Gustaaf Van Tendeloo, Universiteit Antwerpen, Antwerpen, Belgium
Asst. Prof. Miran Čeh, Dr. Sašo Šturm
6. Complex Metallic Alloys
CMA, 6. FP, NMP3-CT-2005-500140
EC; Centre National de la Recherche Scientifique, Paris, France
Prof. Spomenka Kobe, Prof. Janez Dolinšek, Dr. Peter Panjan
7. Strengthening the Role of Women Scientists in Nano-Science
WOMENINANO, 6. FP, SAS6, 016754
EC; Dr. Annett Gebert, IFW Dresden, Leibniz-Institut für Festkörper- und Werkstofforschung Dresden E.V., Dresden, Germany
Prof. Spomenka Kobe
8. Development of Ceramic Matrix Composite for Advanced Nuclear Applications, with an SiC Continuous Fiber Reinforcement and a Nanostructured Carbide Matrix, Processes by the Electrophoretic Infiltration
1000-07-380046
Dr. Jérôme Canel, Commissariat à l'énergie atomique - CEA Saclay, Gif-sur-Yvette, France
Asst. Prof. Saša Novak Krmpotić
9. SiC Coating for Hybrid Thermal Protection Systems for ESA
Subcontract Agreement
Dr. George Vekinis, The National Centre of Scientific, Research "Demokritos", Aghia Paraskevi, Athens, Greece
Asst. Prof. Saša Novak Krmpotić
10. Fuel Storage Nano-Composites Fabricated by Pulse Laser Deposition - PLD
BI-GR-04-06-019
Prof. A. C. Cefalas, National Hellenic Research Foundation, Theoretical and Physical Chemistry Institute, Athens, Greece
Prof. Spomenka Kobe
11. Precipitation of Calcium Carbonate in the Magnetic Field
BI-HR/05-06-031
Dr. Sc. Damir Kralj, Rudjer Bošković Institute, Zagreb, Croatia
Prof. Spomenka Kobe
12. Influence of Quantum Effects on Vibrational Properties of Nano-crystalline Silicon
BI-HR/07-08-028
Dr. Davor Gracin, Rudjer Bošković Institute, Zagreb, Croatia
Asst. Prof. Miran Čeh
13. Hydrogen Storage in Ni-Ti-Zr-Hf Quasicrystals
BI-HR/06-07-020
Dr. Muhamed Sućeska, Dr. Maša Rajjić Linarić, Brodarski Institut, Laboratorij za termičku analizu, Zagreb, Croatia
Dr. Paul McGuinness
14. Study of Remodelling of Bone-ceramic Interface to Assess Cell Growth Kinetics as a Function of Composition and Morphological Modification of Ceramic Implant
BI-IN/06-07-009
Prof. Basu Debabrata, Central Glass & Ceramic Research Institute, Calcutta, India
Dr. Nina Daneu
15. Structural and Chemical Characterization of Titanate-based Nanorods and Nanotubes
BI-CN/07-09-006
Prof. Hui Gu, Shanghai Institute of Ceramics, Shanghai, China
Asst. Prof. Miran Čeh
16. Electronic Ceramics with Interface Control of Electrical Properties
BI-CN/05-07/006
Prof. Hui Gu, Shanghai Institute of Ceramics, Shanghai, China
Asst. Prof. Miran Čeh
17. Environmental Hydrogen-based Recycling of Nd-Fe-B Magnets
BI-CN/05-07/008
Dr. Gaolin Yan, Harbin Institute of Technology, ShenZhen Graduate School, XiLi, ShenZhen, China
Dr. Paul McGuinness
18. Low Pressure Injection Molding of Near-Net Shaped Piezoelectric Ceramics
U3-MM/K6-06-028
Dr. Jae-Ho Jeon, Korea Institute of Machinery and Materials (KIMM), Ceramic Materials Group, Sangnam-Dong, Changwon, Korea
Asst. Prof. Miran Čeh, Prof. Tomaz Kosmač
19. Development of Single Crystalline and Electroceramic Materials by Sintering Process
BI-TR/05-08-002
Prof. Mehmet Ali Gülgün, Sabanci Üniversitesi, Orhanli Tuzla, Istanbul, Turkey
Asst. Prof. Miran Čeh
20. Texturing and Characterisation of ZnO-based Ceramics
BI-TR/05-08-003

Prof. Ender Suvaci, Anadolu University, Department of Materials Science and Engineering, Eskisehir, Turkey
Dr. Slavko Bernik

R & D GRANTS AND CONTRACTS

1. Layered ceramic nanostructures and 2D nanoparticles arrays
Asst. Prof. Miran Čeh
2. Fabrication of novel thin films by pulser-laser ablation with in situ ICP-MS analysis of target plumes for deposition control
Prof. Spomenka Kobe
3. Nanostructural engineering of semiconducting materials
Dr. Aleksander Rečnik
4. The influence of magnetic structure of the materials on the magnetocaloric effect
Dr. Matej Komelj
5. Exploration and preservation of Slovenian mineralogical heritage
Dr. Aleksander Rečnik
6. Application of new technologies to prevent scaling in industrial flow systems
Prof. Spomenka Kobe
7. Rare-earth-transition-metal alloys for high-energy permanent magnets and metal-hydride batteries
Dr. Paul McGuinness
8. Research of degradation mechanisms and improvement of properties of metallized film capacitors
Asst. Prof. Miran Čeh
9. Low-doped ZnO-based ceramics for energy varistors
Dr. Slavko Bernik
10. Development of tissue engineered bone for use in periodontology, traumatology and orthopaedic surgery
Asst. Prof. Miran Čeh
11. Hard magnetic Co-Pt thin films produced with electrodeposition
Prof. Spomenka Kobe, Dr. Kristina Žužek Rožman
12. A development of low-activation material for the first wall in fusion reactor
Asst. Prof. Saša Novak Krmpotić
13. Ecotechnological 1D nanomaterials: Synthesis and characterisation of 1D titanate nanomaterials doped with transition metal ions
Dr. Sašo Šturm, Dr. Polona Umek
14. New generation of elements and devices for protection against transient surges (CoE Materials for electronics of next generation and other emerging technologies)
Dr. Slavko Bernik
15. Magnetic materials and intermetallic alloys (CoE Materials for electronics of next generation and other emerging technologies)
Prof. Spomenka Kobe
16. Nanostructured surfaces and interfaces (CoE Nanosciences and nanotechnologies)
Asst. Prof. Goran Dražić
17. Characterization on the nanometric scale (CoE Nanosciences and nanotechnologies)
Asst. Prof. Miran Čeh

RESEARCH PROGRAM

1. Nanostructured materials
Prof. Spomenka Kobe

NEW CONTRACTS

1. Cooling systems based on magneto-caloric effect
PROKOL d.o.o., Idrija
Prof. Spomenka Kobe
2. Low-doped ZnO-based ceramics for energy varistors
Iskra Zaščite d.o.o., Ljubljana
Dr. Slavko Bernik
3. Low-doped ZnO-based ceramics for energy varistors
Varsi, d.o.o., Ljubljana
Dr. Slavko Bernik
4. VIZIPIN: A safe infrastructure for command and control
Varsi, d.o.o., Ljubljana
Dr. Slavko Bernik

VISITORS FROM ABROAD

1. Karl Höhener, Dipl. Eng., Annemarie Gemperli, MBA, Temas AG, Arbon, Switzerland, 30 January 2007
2. Dr. George Vekinis, Advanced Ceramic Laboratory, Institute for Materials Science, National Center for Scientific Research "Demokritos", Athens, Greece, 9 February 2007
3. Ilaria Corni, Dr. Oana Bretcanu, Department of Materials, Imperial College London, London, United Kingdom, 25 March - 1 April 2007

4. Dr. Damir Kralj, Institut Rudjer Bošković, Zagreb, Croatia, 20 April 2007
5. Dr. Mehmet Ali Gülgün, Sabanci University, Istanbul, Turkey, 3 - 10 May 2007
6. Dr. Goran Branković (4 June - 30 November 2007) and Dr. Zorica Branković (8 June - 1 September 2007), Ms. Milica Počuča (4 - 16 June 2007), Centar za multidisciplinarnu studije, Univerzitet u Beogradu, Belgrade, Serbia
7. Dr. Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 3 April 2007 - 31 March 2008
8. Dr. Boriana Rashkova, Erich Smid Institut für Materialwissenschaft und Montanuniversität Leoben, Leoben, Austria, 11 - 13 July 2007

9. Dr. Mithlesh Kumar Sinha (30 July – 14 August 2007) Dr. Jui Chakraborty (30 July – 28 September 2007) Central Glass & Ceramic Research Institute, Calcutta, India
10. Dr. George Vekinis, Advanced Ceramic Laboratory, Institute for Materials Science, National Center for Scientific Research "Demokritos", Athens, Greece, 23 – 26 August 2007
11. Dr. Jae-Ho Jeon, Korea Institute of Machinery and Materials – KIMM, Changwon-city, Kyeongnam, South Korea, 1 – 5 September 2007
12. Dr. Ender Suvaci, Anadolu University, Department for Materials Science and Engineering, Eskişehir, Turkey, 2 – 6 September 2007
13. Prof. Jozef Vleugels, Prof. Omer Van der Biest, Tina Mattheys and Prof. Lieve Van Mellaert, Katholieke Universiteit Leuven, Leuven, Belgium, Dr. Monika Willert-Porada, Dr. Thorsten Gerdes, Andreas Rosin and Elke Fuchs, Universitaet Bayreuth, Bayreuth, Germany, Jordi Garcia-Forga, Peyer Fertigungstechnik AG, Waltenschwil, Switzerland, Prof. Pieter Luyptaert, Microwave Energy Applications Company NV, Leuven, Belgium, Dr. Martin Erdtmann, HEMOTEQ GmbH, Würselen, Germany, Prof. V. Spitas, Institute of Mechanics of Materials and Geostuctures - IMM SA, Penteli, Greece, Prof. Michael Gasik, Helsinki University of Technology, Espoo, Finland, Dr. Alessandro Pacchini and Dr. Michele Pressacco, LIMA-LTO S.P.A., S. Daniele D.F., Italy, Barbara Lebar-Rjazancev, Marko Gradišar and Katja Kolman, HELI PRO d.o.o., Lesce, Slovenia, Dr. Nevenka Kregar-Velikonja and Dr. Hana Krečič Stres, EDUCCELL, Ljubljana, Slovenia, Matej Andoljšek, Dr. Med., General Hospital Jesenice, Jesenice, Slovenia, Dr. Maja Remškar, Dept. Condensed Matter Physics, Jožef Stefan Institute, Ljubljana, Slovenia, 20 – 21 September 2007
14. Prof. Gerhard Dehm and Daniel Kiener, Erich Smid Institut für Materialwissenschaft und Montanuniversität Leoben, Leoben, Austria, 27 – 28 September 2007
15. Dr. Ulrike Wolff, Leibniz-Institut für Festkörper- und Werkstoffforschung, Dresden, Germany, 13 – 16 November 2007
16. Dr. Petr Klouček, Institut de Mathématiques, Université de Neuchâtel, Neuchâtel, Switzerland, 19 – 21 November 2007
17. Dr. Thierry Sikora, Centre d'Elaboration de Matériaux et d'Etudes Structurales, Toulouse, France, 4 – 6 December 2007
18. Dr. Davor Gracin, Institut Rudjer Bošković, Zagreb, Croatia, 6 December 2007
19. Dr. Jérôme Canel and Dr. Aurélie Coupe, Commissariat à l'Énergie Atomique - CEA Saclay, DEN/DMN/SRMA/LTME, Gif-sur-Yvette, France, 17 – 18 December 2007
20. İsmail Özgür Özer, Anadolu University, Department for Materials Science and Engineering, Eskişehir, Turkey, 16 – 23 December 2007

STAFF

Researchers

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2. Asst. Prof. Miran Čeh**
3. Dr. Nina Daneu
4. Asst. Prof. Goran Dražič**
5. **Prof. Spomenka Kobe**, Head**
6. Dr. Matej Komelj**
7. Asst. Prof. Paul John McGuinness
8. Asst. Prof. Saša Novak Krmpotič**
9. Dr. Aleksander Rečnik**
10. Dr. Sašo Šturm

Postdoctoral associates

11. Dr. Vesna Šrot, left 1.2.2007
12. Dr. Kristina Zužek Rožman

Postgraduates

13. Nataša Drnovšek, B. Sc.
14. Andraž Kocjan, B. Sc.
15. Katja König, B. Sc.
16. Blaž Miklavič, B.Sc.
17. Katarina Rade, B.Sc.
18. Tea Toplišek, B. Sc.
19. Kristina Žagar, B. Sc.
20. Sanja Fidler, univ. B. Sc.
21. Medeja Gec, B. Sc.
22. David Jezeršek, B. Sc., left 30.9.2007
23. Matejka Podlogar, B. Sc.
24. Benjamin Podmiljšak, B. Sc.
25. Dr. Zoran Samardžija

** Part-time faculty member

DEPARTMENT FOR ADVANCED MATERIALS

K-9

Research in the Advanced Materials Department is focused mainly on synthesizing and characterizing new inorganic materials. The emphasis is on investigations of high-temperature phase equilibria, the identification of new compounds, and determining their crystal structures and properties. Investigations relating to ceramics with special electrical and magnetic properties and super-hard materials and glasses are of primary importance. In recent years, nanomaterials and nanotechnologies have become an important part of the department's activities.



Head:
Prof. Danilo Suworov

In 2007 the investigations of the program group P2-0089 were directed to four important materials, i.e., magnetic nanoparticles for applications in technology and medicine, microwave magnetic ceramics for use in the area of telecommunications, semiconducting spintronic materials based on ZnO, and ferroelectric materials with a high Curie temperature for the preparation of high-temperature thermistors that would replace lead-containing materials.

The research on magnetic nanoparticles was mainly focused on their functionalization. For biomedical applications, the magnetic nanoparticles should be functionalized with a surface layer of organic molecules, which enables the selective bonding of different bioactive molecules to their surfaces, allows their compatibility with physiological fluids and prevents their agglomeration. The bonding of different organosilane molecules directly onto the nanoparticles' surfaces or on the surface layer of silica was systematically studied. We have continued with the research of different methods of nanoparticle syntheses, especially methods based on the thermal decomposition of organo-metal complexes and the method of hydrothermal synthesis.

In the field of magnetic materials for telecommunications the studies were focused on the development of materials suitable for magnetic microwave and mm-wave devices. The possibility of low-temperature co-firing ceramics (LTCC) based on Z-hexaferrites was studied. We showed that the compositions suitable for LTCC and compatible with Ag are thermally unstable at 900–950°C. We proposed a mechanism for the Z-hexaferrites degradation based on a defect crystal chemistry. The influence of the partial degradation of hexaferrites on the electromagnetic behaviour was also evaluated. A new method for the synthesis of single-phase W-hexaferrites suitable for mm-wave applications was developed. The method is based on a two-step synthesis via intermediates. Based on this method, new nonreciprocal isolators (8x smaller than the state of the art) were developed in cooperation with TKI-Ferrit (Hungary). In 2007 we started with the development of a new type of electromagnetic absorbers using spraying technology and with the development of thick M-hexaferrite films for applications above 30 GHz.

In the field of spintronic materials, high-temperature reactions, phase relations, structures and properties of different spinel phases in the ZnO–MnO_x system were studied. This research is important for understanding the magnetism of the semiconducting solid solutions of magnetic ions in ZnO.

In the field of high-temperature thermistors the processes of reduction and reoxidation related to the formation of temperature-dependent potential barriers at the grain boundaries of ferroelectric ceramics in the BaTiO₃–BaNb₂O₆ system were studied.

Investigations in the program group P2-0089 Advanced Materials and Nanotechnologies for 2007 were made on low-sinterable, low-permittivity and low-loss materials based on K_xBa_{1-x}Ga_{2-2x}Ge_{2+x}O₈ solid solutions with the paracelsian structure (P2_v/a) and materials with the scheelite structure. We found that during the phase transition from the P2_v/a to the C2/m modification the dielectric properties of K_xBa_{1-x}Ga_{2-2x}Ge_{2+x}O₈ solid solutions changed; in particular the dielectric losses increased. With knowledge of the kinetics of the phase transitions and with the help of a minimal addition of the sintering aid, dense, low-permittivity material ($\epsilon=5.0-6.1$) with a sintering temperature of 900–970°C, Qxf values of 110 000 to 150 000 GHz and a temperature coefficient of resonant frequency (τ_f) of around -20 ppm/K was prepared. During a study of materials with the scheelite structure several new findings were made. One of them is the possibility to sinter under LTCC conditions. It was found that SrWO₄ is, in contrast to BaWO₄ and CaWO₄, hygroscopic. For practical applications this property is a major disadvantage.

With the cooperation of EPCOS Ohg., Deutschlandsberg, Austria, we developed a series of high-, middle- and low-dielectric ceramic materials on the basis of Bi-compounds for LTCC technology, which have shown various functional dielectric properties and a chemical compatibility between themselves and silver electrodes. The developed dielectric ceramic materials are protected with 12 international patents and were transferred to the regular production of multifunctional LTCC modules.

- **Synthesis and functionalization of magnetic nanoparticles for applications in biomedicine.**
- **LTCC hexaferrite ceramics for microwave applications.**
- **Development of a two-step synthesis for W-hexaferrites and for new nonreciprocal isolators for mm-wave applications.**
- **Structures and properties of spinel phases in the ZnO-MnO_x system.**

Part of the low-dielectric-materials research work involved studying the re-crystallization process for various compositions of the MgO-B₂O₃-SiO₂ system. This system is extremely interesting because of the applicable potential in LTCC technology, and it remains undiscovered. The majority of the experimental work was focussed on the following composition: 43 wt.% MgO, 35 wt.% B₂O₃, and 22 wt.% SiO₂. We confirmed that a higher sintering temperature also resulted in a smaller amount of glassy phase, which affects the dielectric properties. Increasing the sintering temperatures and a longer milling time has the effect of decreasing the permittivity. The lowest value of the permittivity, 4.7, achieved for 1000°C/5h. The highest value of Qxf was 9400GHz, which was achieved with a sintering temperature of 950°C.

Besides the above-mentioned research on low-dielectric materials, we also investigated the voltage-tunable characteristics of ferroelectric materials. We focused on the tunability of the dielectric constant, which is defined as the relative change of a dielectric constant under a DC-bias field ($n_r = (\epsilon(0) - \epsilon(E)) / \epsilon(0)$). Voltage-tunable materials are applicable in many radio-frequency and microwave electronic components, such as varactors, phase shifters, tunable filters, tunable resonators, etc. In our work we focused on relaxor ferroelectrics, especially on Na_{0.5}Bi_{0.5}TiO₃-based compounds. We determined the tunability of the dielectric constant for the Na_{0.5}Bi_{0.5}TiO₃-NaTaO₃ homogeneity region. As the concentration of NaTaO₃ increases from 0 to 10 mol% the tunability increases from 36% up to almost 50%. However, as the concentration of the additive increases further the tunability gradually decreases to 22%. High values of the tunability are related to the morphotropic compositions of the samples and the maximum dielectric relaxations. Samples with a high tunability were shown to also exhibit high dielectric losses and vice versa. The reduction of the dielectric losses relates to a decrease of the polar-cluster size. Samples with a high NaTaO₃ concentration also show a moderate temperature coefficient of the dielectric constant and are therefore attractive for practical applications.

As part of the research on voltage-tunable ferroelectric materials, we constructed a system for testing the axial pressure dependence of the permittivity and characterized this dependence for materials from the Na_{0.5}Bi_{0.5}TiO₃-NaTaO₃ system. Later we concentrated on the synthesis of the Na_{0.5}Bi_{0.5}TiO₃-KTaO₃ solid solution, in which the formation of the secondary phase takes place and is characteristic for the K_{0.5}Bi_{0.5}TiO₃ system. With the addition of NaTaO₃ we managed to increase the effect of the axial pressure on the permittivity, which was our basic objective in the research. During this testing, the mechanical polarization of the samples was observed, as the permittivity of the samples after the tests did not reach the value prior to testing. This is a consequence of the ferroelastic domain switching caused by the axial stress, which also changes the ferroelectric domain structure and influences the dielectric properties of the sample. Although in the Na_{0.5}Bi_{0.5}TiO₃-NaTaO₃ system single-phase ceramics can be prepared by the solid-state method, a secondary phase is formed in materials from the Na_{0.5}Bi_{0.5}TiO₃-KTaO₃ system prepared by a conventional method.

In the field of investigating the stabilization mechanism of the perovskite La_{2/3}TiO₃ compound, which is unstable due to the A-site vacancies, we confirmed that the addition of Fe₂O₃ stabilizes the perovskite La_{2/3}TiO₃. A single-phase ceramic is formed by the addition of 4 mol% LaFeO₃. This prepared La_{2/3}TiO₃ phase forms a solid solution with LaFeO₃ across the entire concentration range. Ceramics based on the La_{2/3}TiO₃-LaFeO₃ solid solution were characterized using impedance spectroscopy, in accordance with the composition and synthesis conditions. We found that the composition

with 30 mol% of LaFeO₃ exhibited the highest electrical conductivity, which was $\rho = 0.0017 \text{ Scm}^{-1}$ and so this material is a potential candidate for the cathode in a SOFC. In addition, we determined the subsolidus phase relations in the ternary La₂O₃-TiO₂-Fe₂O₃ system at 1300°C.

As part of the research on perovskite compounds, we focused on a study of the polymorphic phase transitions and the phase stability of Ba₄Nb₂O₉ polymorphs. We have isolated hexagonal (α) and two orthorhombic (γ , β) modifications and estimated the phase-transition temperature between them. The γ -modification was identified as the low-temperature polymorph, stable below 1160°C, while above this temperature the stable polymorph is the γ . The β -modification was identified as a metastable low-temperature phase, observed below 300°C after reheating the γ -modification. Transmission electron microscopy (TEM) revealed an intergranular BaO-rich amorphous phase and a nanocrystalline Ba₅Nb₄O₁₅ in all the polymorphs, most abundantly in the α -modification. Collected high-resolution scanning electron images and electron-diffraction patterns along different low-index zone axes allowed us to propose the

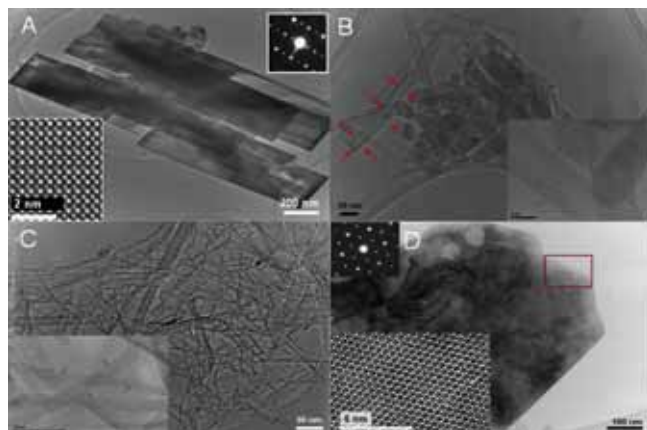


Figure 1: HRTEM images of A) well-crystallized plate-like crystals of CaTiO₃ and intermediate phases: B) partly crystallized nanowires and C) nanotubes and D) well-crystallized single-crystalline thin sheets

crystal-structural model and prove the presence of superstructure ordering in the α -modification. Regarding the stoichiometry of the $\text{Ba}_4\text{Nb}_2\text{O}_9$ compound and the discrepancy in the distance between the Ba-O layers along the hexagonal c -axis with respect to this distance in the conventional perovskite structures, we proposed a crystal-structural model that is closely related to the 2H-type perovskite structure. The proposed structure comprises alternating Ba_3O_9 and oxygen-deficient Ba_3O_6 close-packed layers along the c -axis. Such stacking of the close-packed layers creates the infinite chains of octahedrally and trigonal-prismatically coordinated B-site cations. Based on the data collected by SAED and HRTEM we confirmed the validity of the chosen structural model and measured the unit-cell parameters ($a = 1.023 \text{ nm}$ and $c = 0.846 \text{ nm}$). Furthermore, the electron-diffraction patterns in the prismatic [010] zone axis revealed the presence of satellite reflections, the reciprocal-space vectors of which are slightly inclined with respect to the vectors of the main diffraction spots, indicating that the crystal structure of the α -modification is incommensurate.

Investigations were also made on the dielectric properties of pyrochlore-type solid solutions in the system $\text{Bi}_2\text{O}_3\text{-TiO}_2\text{-RE}_2\text{O}_3$ (RE = Y or Nd), which form in the following concentration range: $\text{Bi}_{(1.6-0.8x)}\text{Y}_x\text{Ti}_2\text{O}_{(6.4+0.3x)}$ ($0.03 < x < 2$) and $\text{Bi}_{(1.6-1.08x)}\text{Nd}_x\text{Ti}_2\text{O}_{(6.4+0.11x)}$ ($0.25 < x < 0.96$). The results of the dielectric measurements (1MHz) showed that the $\text{Bi}_{(1.6-0.8x)}\text{Y}_x\text{Ti}_2\text{O}_{(6.4+0.3x)}$ pyrochlore solid solution ($\epsilon = 127.1$, $x = 0.06$) has higher values of dielectric constant (ϵ) than the $\text{Bi}_{(1.6-1.08x)}\text{Nd}_x\text{Ti}_2\text{O}_{(6.4+0.11x)}$ pyrochlore solid solution ($\epsilon = 103.5$, $x = 0.35$). The dielectric constant (ϵ) decreases with the increase of Y_2O_3 or Nd_2O_3 in the pyrochlore solid solution. With both pyrochlore solid solutions the dielectric loss ($\tan\delta$) is below 0.008. We observed similar behaviour for the dielectric properties at different frequencies.

The research also included a study and analysis of the pyrochlore formation in the ternary $\text{Bi}_2\text{O}_3\text{-TiO}_2\text{-WO}_3$ system. It has been revealed that the bismuth-titanate phase in the system can be stabilized by additions of W^{6+} ions, which incorporate on the B site in the crystal structure with the charge compensation occurring mainly through the formation of A-site vacancies in the pyrochlore structure. The results of our investigations suggest that by following such an incorporation mechanism a single-phase ceramic might be prepared with up to 8 mol % of WO_3 added, while further WO_3 additions result, besides the pyrochlore phase, also in the presence of kinetically based unstable secondary phases. Based on our results it can be concluded that W^{6+} incorporation occurs for up to 13 % of added WO_3 . By analysing the $\text{Bi}_6\text{Ti}_5\text{TeO}_{22}$ compound we discovered that an isostructural compound can be formed by replacing the Te^{6+} by W^{6+} , thus forming the $\text{Bi}_6\text{Ti}_5\text{WO}_{22}$ compound. The former compound exhibits an even larger permittivity than the $\text{Bi}_6\text{Ti}_5\text{TeO}_{22}$ and a similarly large temperature coefficient of resonant frequency, which can, however, be tuned with isovalent substitutions of the Bi^{3+} ions by Y^{3+} and Nd^{3+} . With suitable additions the solid solutions can be formed, which allows the tuning of the dielectric properties of the obtained ceramics.

In addition to the investigations of dielectric materials, we also studied inorganic thin films, such as $\text{Bi}_{12}\text{SiO}_{20}$ and $\text{Bi}_{3-3y}\text{Nb}_{1+y}\text{O}_{7+y}$. The preparation of $\text{Bi}_{12}\text{SiO}_{20}$ (BSO) thin films involved the sol-gel method. Thin films of BSO were coated on various substrates, such as sapphire (Al_2O_3), $\text{Si/SiO}_2/\text{TiO}_2/\text{Pt}$ and spinel (MgAl_2O_4). Results have shown that the most homogeneous BSO thin films are obtained on $\text{Si/SiO}_2/\text{TiO}_2/\text{Pt}$ substrates, less homogeneous films were formed on spinel, and on sapphire the thin films were very porous. The thickness of the BSO thin film increased from 200 nm on the $\text{Si/SiO}_2/\text{TiO}_2/\text{Pt}$ substrate to 300 nm on the spinel, and up to 400 nm on the sapphire substrate. However, the grain size of the thin films on the $\text{Si/SiO}_2/\text{TiO}_2/\text{Pt}$ substrate was around 1 μm , whereas for the spinel and sapphire substrates it was about 200 nm.

In the case of the preparation of solid-solution $\text{Bi}_{3-3y}\text{Nb}_{1+y}\text{O}_{7+y}$ ($0.2 < y < 0.04$) thin films and powders we used the Pechini method. In the first stage of the synthesis we prepared metallic precursors, which we then esterified with the addition of ethylene glycol. The gels were heat treated at different temperatures to obtain $\text{Bi}_{3-3y}\text{Nb}_{1+y}\text{O}_{7+y}$ thin films or powders. Low calcination temperatures ($\leq 500^\circ\text{C}$) led to the formation of cubic structured $\text{Bi}_{3-3y}\text{Nb}_{1+y}\text{O}_{7+y}$, whereas at higher temperatures the tetragonal structure is obtained. In both cases the powders have nanosized particles. In the so-prepared $\text{Bi}_{3-3y}\text{Nb}_{1+y}\text{O}_{7+y}$ thin films or powders the phase transformation from the cubic to tetragonal structure also occurred, but it was comparably faster than the one in the "bulk" samples.

Part of the thin-film research was done on a titanium dioxide (TiO_2) thin film, which was prepared by the in-situ-modified sol-gel method in a pre-fabricated organic template. The organic template was fabricated by the layer-by-layer self-assembly method, where the PE multilayer is formed by the sequential adsorption of oppositely charged polyelectrolytes. The template thickness can be tuned at the nanometre level, depending on the number of polyelectrolyte layers deposited, which provides a means to control the final TiO_2 film thickness. After calcination at 500°C for 1 hour the TiO_2 particles are expected to coalesce, resulting in a relatively dense, uniform anatase TiO_2 film, with the thickness controlled on the nanometre scale. The TiO_2 particle size was determined to be below 10 nm.

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- **The preparation of environment-friendly lead-free thermistors on the basis of ferroelectric ceramics from the $\text{BaTiO}_3\text{-BaNb}_2\text{O}_6$ system.**
 - **Investigations on low-sinterable, low-dielectric materials in the $\text{MgO-B}_2\text{O}_3\text{-SiO}_2$ system and solid solutions based on $\text{K}_x\text{Ba}_{1-x}\text{Ga}_{2-2x}\text{Ge}_{2+2x}\text{O}_8$.**
 - **Investigation of the voltage-tunable ferroelectric materials with electrical fields and axial pressure in the $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-NaTaO}_3$ and $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-KTaO}_3$ systems.**
 - **Study of polymorphic phase transitions and phase stability for $\text{Ba}_4\text{Nb}_2\text{O}_9$ polymorphs.**
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Some of our research was focused on an investigation of the formation mechanism of 1D nanostructured calcium titanate, and from titanium(IV) isopropoxide and a calcium acetate aqueous solution in a highly alkaline environment we introduced the hydrothermal method. As a result of low-temperature reactions performed at different times we observed the formation of nanostructured CaTiO_3 with layered, well-crystallized single crystals and intermediate phases, which formed as amorphous nanoparticles, thin, well-crystallized nanostructured sheets, partly crystallized nanowires, and partly crystallized nanotubes. We determined the morphology and the crystal structure of the formed phases by the use of high-resolution transmission electron microscopy (HRTEM). For a

- Investigated the dielectric properties of pyrochlore-type solid solutions in the system $\text{Bi}_2\text{O}_3\text{-TiO}_2\text{-RE}_2\text{O}_3$ (RE= Y or Nd).
- Preparation of $\text{Bi}_{12}\text{SiO}_{20}$ thin films by the sol-gel method and TiO_2 thin films by the in-situ-modified sol-gel method in a pre-fabricated organic template.
- Preparation of CaCO_3 nanoparticles with a biomimetical synthesis.
- Investigation of hard materials of Al-Ti alloys with a ceramic component TiB_2 , B_4C and TiC .

determination of the composition and the electronic structure of the phases we performed electron energy-loss spectroscopy (EELS) and the energy-loss near-edge structure (ELNES) analysis on the Ti-L_{2,3} and O-K edge. We determined that the nanotubes have a composition and an electronic structure closer to TiO_2 . The amorphous nanoparticles, nanostructured sheets and nanowires all contained titanium and calcium, but they differed in terms of morphology, crystal structure and composition.

Using a biomimetical synthesis reaction from chloride solutions we prepared CaCO_3 nanoparticles and studied the particles' growth mechanism and the influence of Mg on the particles' growth.

We started with experimental work in the field of hard materials, where we investigated the properties of composites based on different Al-Ti alloys and ceramic components, such as TiB_2 , B_4C and TiC .

In the research area of glass, the investigations were made for several industrial partners, such as TERMO, Heraklith, Paroc and Gamma Meccanica. Research included analyses of mineral rocks, glassy materials and fibres. The basic aim of the investigations was to determine the correlations between the composition and the glass-forming conditions in order to obtain the optimal melt properties of the glass for the production of fibres. We performed numerous melting tests on the samples to analyse the melting behaviour of various basalts and their compositions with dolomites. Part of investigation was also made on the thermal stability of mineral fibres.

In the scope of the industrial research projects carried out in collaboration with EPCOS Ohg. from Austria, we developed low- and middle-permittivity LTCC materials, which are compatible with the already-developed high-permittivity materials. The developed materials were shown to have chemical compatibility, as well as matching thermal expansion coefficients and sintering behaviour.

Some outstanding publications in 2007

1. Jakob König, Boštjan Jančar, Danilo Suvorov. New $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-NaTaO}_3$ -based perovskite ceramics. J. Am. Ceram. Soc., 2007, vol. 90, no. 11, pp. 3621–3627. [COBISS.SI-ID 21351975]
2. Manca Logar, Boštjan Jančar, Danilo Suvorov, Rok Kostanjšek. In situ synthesis of Ag nanoparticles in polyelectrolyte multilayers. Nanotechnology (Bristol), 2007, vol. 18, pp. 325601–1–32506-7. [COBISS.SI-ID 20902951]
3. Marjeta Maček, Anton Meden, Danilo Suvorov. The correlation between the structure and the dielectric properties of $\text{K}_x\text{Ba}_{1-x}\text{Ga}_{2-x}\text{Ge}_{2+x}\text{O}_8$ ceramics. J. Eur. Ceram. Soc., 2007, vol. 27, issues 8–9, pp. 2957–2961. [COBISS.SI-ID 20703527]
4. Matjaž Spreitzer, Matjaž Valant, Danilo Suvorov. Sodium deficiency in $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$. J. mater. chem., 2007, vol. 17, pp.185–192. [COBISS.SI-ID 20412199]
5. Darja Lisjak, Mihael Drofenik. Thermal stability of (Co, Cu)Z-hexaferrite and its compatibility with Ag at 900°C. J. Am. Ceram. Soc., 2007, vol. 90, no. 11, pp. 3517–3521. [COBISS.SI-ID 21182759]

Patents granted

1. Keramisches Material, gesinterte Keramik und Bauelement daraus, Verfahren zur Herstellung und Verwendung der Keramik
Pavol Dudašek, Bad Gams, Christian Hoffmann, Danilo Suvorov, Matjaž Valant
München, Deutsches Patent-und Markenamt, 2007.
2. UA patent 78081
Composite microwave dielectric material based on magnesium titanate and calcium titanate
Grigorovič, Bilous Anatoli, Ovchar, Oleg V., Oleksandrovič, Durilin Dmitro, Maček-Kržmanc, Marjeta, Valant, Matjaž, Suvorov, Danilo
Kiev: Ukraine State Department of Intellectual Property

- Patent DE 10325008.5
Elektrisches Bauelement und dessen Herstellung
Valant, Matjaž, Heinz, Florian, Gams, Bad, Reichmann, Klaus, Suvorov, Danilo
München: Deutsches Patent- und Markenamt

Awards and appointments

- Ines Bračko: Young scientists award, 15th Conference on materials and technology, Portorož, 8–10 October 2007, Institute of metals and technology, oral presentation: Understanding the formation of nanostructured perovskite CaTiO_3 under hydrothermal conditions.
- Jakob König: Young scientists award, 15th Conference on materials and technology, Portorož, 8–10 October 2007, Institute of metals and technology, oral presentation: Increasing the effect of axial pressure on the permittivity of $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ by adding NaTaO_3 .
- Matjaž Spreitzer: Award for the best oral presentation, Herceg Novi, Montenegro, Yugoslav Materials Research Society, oral presentation: Influence of crystal symmetry on the volt-age-tunability of $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ -based systems.
- Matjaž Spreitzer: Award for the best paper contribution, Nara, Japan, The Committee of the 16th IEEE International Symposium on the Applications of Ferroelectrics, oral presentation: $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ -based voltage-tunable materials.

Organization of conferences, congresses and meetings

- XV. Conference on Materials and Technologies, 8. 10.–10. 10. 2005, Portorož, Slovenia (co-organizers)
- Materials Science and Technologies Conference, 15. 9.–21. 9. 2007, Detroit, USA (co-organizers)

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The correlation between the structure and the dielectric properties of $\text{K}_{x}\text{Ba}_{1-x}\text{Ga}_{2x}\text{Ge}_{2-x}\text{O}_8$ ceramics
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22. Marjeta Maček, Matjaž Valant, Danilo Suvorov
The synthesis and microwave dielectric properties of $Sr_{1-x}Ba_xAl_2Si_2O_8$ and $Ca_yBa_{1-y}Al_2Si_2O_8$ ceramics
In: J. Eur. Ceram. Soc., Vol. 27, no. 2-3, pp. 1181-1185, 2007.
23. Darko Makovec, Irena Pribošič, Mihael Drogenik
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In: Ceram. int., Vol. 34, no. 1, pp. 89-94, 2007.
24. I. Nikčević, D. Maravić, N. Ignjatović, Miodrag Mitrić, Darko Makovec, Dragan P. Uskoković
The formation and characterization of nanocrystalline phases by mechanical milling of biophasic calcium phosphate/poly-L-lactide biocomposite
In: Mater. trans., Vol. 47, no. 12, pp. 2980-2986, 2007.
25. Massimo Pasquale, Sergio Perero, Darja Lisjak
Ferromagnetic resonance and microwave behavior of ASn-substituted (A=Ni-Co-Zn)BaM-hexaferrites
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26. M. Peiteado, A. C. Caballero, Darko Makovec
Diffusion and reactivity of Zn-O-MnO₂ system
In: J. solid state chem., Vol. 180, pp. 2459-2464, 2007.
27. M. Peiteado, A. C. Caballero, Darko Makovec
Phase evolution of $Zn_{1-x}Mn_x$ system synthesized via oxalate precursors
In: J. Eur. Ceram. Soc., Vol. 27, pp. 3915-3918, 2007.
28. Urša Pirnat, Danilo Suvorov
Dielectric properties and phase transitions of $Bi_{1-x}Nb_xTa_xO_6$ fluorite-type dielectrics
In: J. Eur. Ceram. Soc., Vol. 27, no. 13/15, pp. 3843-3846, 2007.
29. C. Rivero, Marko Udovič, (13 avtorjev)
Influence of modifier oxides on the structural and optical properties of binary TeO_2 glasses
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30. Matjaž Spreitzer, Jakob König, Boštjan Jančar, Danilo Suvorov
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31. Matjaž Spreitzer, Matjaž Valant, Danilo Suvorov
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32. Srečo D. Škapin, Goran Dražič, Zorica Crnjak Orel
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33. Marko Udovič, Danilo Suvorov
Sintering and dielectric characterization of pseudoternary compounds from the Bi_2O_3 - TiO_2 - TeO_2 system
In: J. Am. Ceram. Soc., Vol. 90, no. 8, pp. 2404-2408, 2007.
34. Polona Umek, Romana Cerc Korošec, Boštjan Jančar, Robert Dominko, Denis Arčon
The influence of the reaction temperature on the morphology of sodium titanate 1D nanostructures and a study of their thermal stability
In: J. nanosci. nanotechnol. (Print), 7 p., [in press] 2007.
35. Vuk Uskoković, Mihael Drogenik
Four novel co-precipitation procedures for the synthesis of lanthanum-strontium manganites
In: Mater. eng., Vol. 28, pp. 667-672, 2007.
36. Mojca Žnidaršič, Bojana Dolinar
Ocena koeficientov vodoprepustnosti zasičenih glin na osnovi njihovih fizikalnih lastnosti
In: Geologija, Vol. 50, No. 2, pp. 487-495, 2007.
37. Ines Bračko, Boštjan Jančar, Sašo Šturm, Danilo Suvorov
Razumevanje nastanka nanostrukturirane perovskita $CaTiO_3$ pod hidrotermalnimi pogoji
In: Mater. tehnol., Letn. 41, No. 6, p. 317, 2007.

PUBLISHED CONFERENCE PAPERS

Invited Paper

1. Gorazd Hribar, Andrej Žnidaršič, Marjan Bele, Stanislav Čampelj, Darko Makovec, Miran Gabersček, Vladka Gaberc-Porekar, Peter Venturini
Coordinative binding on different types of nanoparticles
In: Proceedings of the International Conference on Nanotechnology & Health Care Applications: NateHCA-07, T. S. Rathore, ed., Mumbai, IETE Mumbai Centre, 2007, pp. C 30-35.

INTERNATIONAL PROJECTS

1. Controlled Production of High Tech Multifunctional Products and their Recycling
SAPHIR, 6. FP, NMP2-CT-2006-026666
EC; Laurence Demoor, Christophe Goepfert, Compagne Industrielle des Lasers Cilas SA, Orleans, France
Prof. Danilo Suvorov
2. Tantalum-Free Microwave Dielectric Resonators with Enhanced Quality Factor
NATO SFP 980881
NATO Public Diplomacy Division, North Atlantic Treaty Organisation, Brussels, Belgium; Prof. Peter Mascher, McMaster University, Department of Engineering Physics, Faculty of Engineering, Hamilton, Ontario, Canada
Dr. Boštjan Jančar
3. New Generation Microwave Ferrite Thick Films for Absorbers
MATERA ABSOFILM

Regular Papers

1. Anatolii Belous, Oleg V. Ovchar, Boštjan Jančar, Jana Bezjak
The effect of non-stoichiometry on the microstructure and microwave dielectric properties of the columbites $A^2Nb_6O_{16}$
In: Papers Presented at the Fourth International Conference on Microwave Materials and their Applications - MMA2006: Oulu, Finland, 12 - 15 June 2006 (Journal of the European ceramic society, Vol. 27, Issues 8-9, 2007), M. T. Sebastian, ed., Amsterdam, Elsevier, 2007, Vol. 27, no. 8/9, pp. 2933-2936, 2007.
2. Borut Bundara, Marko Udovič, Jelena Vojvodič-Tuma, Leon Cizelj, Bogo Pirš, Robert Cvelbar, Roman Celin, Igor Zabrc, Igor Simonovski
Cooperative project on methods and technics for assessment of ageing and safety of nuclear objects
In: Conference proceedings, International Conference Nuclear Energy for New Europe 2007, Portorož, Slovenia, September 10-13, Igor Jenčič, ed., Melita Lenošek, ed., Ljubljana, Nuclear Society of Slovenia, 2007, 6 str.
3. Darja Lisjak, Andrej Žnidaršič, Anna Sztanislav, Mihael Drogenik
A two-step synthesis of W-hexaferrites
In: Proceedings, ICMF2007, 18th International Conference on Electromagnetic Fields and Materials, 17-18 May, 2007, Budapest, Hungary, [S. I., s. n.], 2007, pp. 93-96.
4. Matjaž Spreitzer, Jakob König, Boštjan Jančar, Danilo Suvorov
 $Na_{0.5}Bi(0.5)TiO_3$ -based voltage-tunable materials
In: ISAF 2007: proceedings of the 16th IEEE International Symposium on Applications of Ferroelectrics, Nara City, Japan, May 27-31, 2007, Takaaki Tsurumi, ed., Tokyo, The Institute of Electrical and Electronic Engineers, Ultrasonic, Ferroelectrics and Frequency Control Society, 2007, pp. 202-204.
5. Sašo Šturm, Boštjan Jančar, Ines Bračko
Towards understanding the hydrothermal synthesis of nanostructured $CaTiO_3$: HRTEM and EELS study
In: Proceedings, 8th Multinational Congress on Microscopy, June 17-21, 2007, Prague Czech Republic, Jana Nebesářová, ed., Pavel Hozák, ed., [Prague], Czechoslovak Microscopy Society, cop. 2007, pp. 165-166.
6. Polona Umek, Matej Pregelj, Alexandre Gloter, Pavel Cevc, Miran Čeh, Urša Pirnat, Denis Arčon
Titanate nanostructures doped with Cu^{2+} ions; EPR and TEM characterization
In: Engineering of crystalline materials properties: state-of-the-art in modelling, design, applications: lecture notes and poster abstracts, 39th Course, a Nato Advanced Study Institute, Erice, Italy, 7 to 17 June 2007, Lia Addadi, ed., Juan Novoa, ed., Dario Braga, Erice, International School of Crystallography, 2007, Zv. 2, pp. 646-647.

PATENT APPLICATION

1. Patent Applications No. 200700122
Postopek priprave magnetnih nanokompozitov z visoko vsebnostjo nanodelcev dispergiranih v polimerni matrici
Makovec, Darko, Gyergyek, Sašo, Huskić, Miroslav, Drogenik, Mihael

THESES

Ph. D. Thesis

1. Urša Pirnat: Phase Transformations of incommensurate-commensurate modulated crystal structures in oxide systems based on Bi_2O_3 (mentor: Prof. Danilo Suvorov)

B. Sc. Theses

1. Slavko Kralj: Use of microcalorimetry and liquid chromatography in preformulation studies of stability of Ramipril (mentor: Prof. Vojko Kmetec)
2. Simona Ovtar: Quantitative determination of amorphous phase in samples of silicon carbide with X-ray powder diffraction (mentor: Prof. Anton Meden)
3. Darinka Primc: Synthesis and transformations of enamione derivatives (mentor: Prof. Branko Stanovnik)
4. Mojca Žnidaršič: Evaluation of permeability of saturated cohesive soils based on their physical properties (mentor: Prof. Breda Mirtič)

ERA-NET, 4302-31/2006/26

Dr. Darja Lisjak

4. Characterisation of Bio Soluble Mineral Fibres
T070032
Markus Mente, B. Sc., Heraklith GmbH, Furnitz, Austria
Prof. Danilo Suvorov
5. Characterization of Bio Soluble Mineral Fibres
N40/06
Ingram Eusch, B. Sc., Heraklith AG, Ferndorf, Austria
Prof. Danilo Suvorov, Dr. Marko Udovič
6. LTCC Materials for High Frequency Applications
T070033
Dr. Justinus Slakhorst, Christian Block, B. Sc., EPCOS OHG, Ceramic Components Division, Deutschlandsberg, Austria
Prof. Danilo Suvorov

7. Temperature Stable Dielectrics with Improved Dielectric Properties T070003
Dr. Christian Hoffmann, EPCOS OHG, Ceramic Components Division, Deutschlandsberg, Austria
Prof. Danilo Suvorov, Dr. Srečo Davor Škapin
8. LTCC Materials for Multilayer LC Filters N0042/06
Dr. Pavol Dudesek, EPCOS OHG, Deutschlandsberg, Austria
Prof. Danilo Suvorov, Dr. Boštjan Jančar
9. Characterization of Bio Soluble Mineral Fibres T070031
Niklas Bergman, B. Sc., Paroc Group OY AB/R&D, Pargas; Vantaa, Finland
Prof. Danilo Suvorov
10. Characterization of Bio Soluble Mineral Fibres N0039/06
Dr. Michael Perander, Paroc Group OY AB/R&D, Pargas; Vantaa, Finland
Prof. Danilo Suvorov, Dr. Marko Udovič
11. Materials with improved High-frequency Magnetic Properties prepared from Silica-coated Ferrites BI-FR/06-PROTEUS-014
Dr. Jean-Lue Rehspringer, Institut de Physique et Chimie des Matériaux, Strasbourg, France
Asst. Prof. Darko Makovec
12. Control of Grain Size and Morphologies of Nanograined Oxides by Adaptation of the Synthesis Route: Precipitation in Microemulsions and Hydrothermal Synthesis BI-FR/06-PROTEUS-010
Asst. Prof. Nadine Millot, LRRS, UMR 5613, CNRS/Université de Bourgogne, Dijon Cedex, France
Asst. Prof. Darko Makovec
13. Characterization of the Materials for Mineral Fibres Production T070001
Giovanni Burini, B. Sc., Gamma Meccanica, Bibbiano, Reggio Emilia, Italy
Prof. Danilo Suvorov
14. Non Conductive Magnetic Materials for Microwave Absorbers BI-IT/05-08-007
Dr. Enzo Ferrara, Istituto Elettrotecnico Nazionale Galileo Ferraris Torino, Torino, Italy
Dr. Darja Lisjak
15. Nanoferrites and Non-reciprocal Devices for Mm-wave Applications BI-HU/06-07/003
Dr. Anna Sztaniszlav, TKI-FERRIT Development and Manufacturing Ltd., Budapest, Hungary
Dr. Darja Lisjak

R & D GRANTS AND CONTRACTS

1. Multifunctional composites based on Al-Mg-Ti intermetallic compounds reinforced with ceramic particles
Prof. Danilo Suvorov
2. Time- and position-controlled release of drug substances coated onto superparamagnetic nanoparticles
Asst. Prof. Darko Makovec
3. Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
Asst. Prof. Darko Makovec
4. Smart functional coatings for increasing sustainability of structures and components for defense purposes
Dr. Srečo Davor Škapin
5. Self-cleaning photocatalytic coatings
Dr. Srečo Davor Škapin
6. Development of multi-functional B4C-Al and B4C-Mg composites for emerging applications
Dr. Srečo Davor Škapin

RESEARCH PROGRAMS

1. Advanced inorganic magnetic and semiconducting materials
prof. Mihael Drofenik
2. Contemporary inorganic materials and nanotechnologies
Prof. Danilo Suvorov

NEW CONTRACT

1. Co-founding of the project »Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids«
Kolektor Magma d.o.o.
Asst. Prof. Darko Makovec

VISITORS FROM ABROAD

1. Dr. Christian Hoffmann, Dr. Wolfgang Statteneter, EPCOS OHG, Deutschlandsberg, Austria, 22. 1. 2007
2. Prof. Hong Wang, Prof. Wei Ren, Dr. Peng Shi, Dr. Huanfu Zhou, Xi'an Jiaotong University, Xi'an, China, 12. 2. 2007
3. Prof. Enzo Ferrara, dr. Elena Olivetti, dr. Sergio Perero, INRIM, Turin, Italy, 26. 3. 2007
4. Dr. Vuk Uskoković, Clarkson University, Potsdam, USA, 18. 5. 2007
5. Burrini Giovanni, B. Sc., Secchi James, B. Sc., Gamma Meccanica, Bibbiano, Italy, 12. 6. 2007
6. Dr. Luc Berger, Fraunhofer Institute, Dresden, Germany, 14. 6. 2007
7. Prof. Robert L. Moreiro, Federal University of Minas Gerais, Belo Horizonte, Brasil, 7. 9. - 8. 9. 2007
8. Prof. Jose Varela, University of Sao Paulo, Sao Paulo, Brasil, 3. 9. - 7. 9. 2007

9. Dr. Nadine Millot, Dr. Anne - Laure Papa, University of Burgundy, Dijon, France, 26. 9. - 29. 9. 2007
10. Dr. Christian Hoffmann, EPCOS OHG, Deutschlandsberg, Austria, 7. 11. 2007
11. Dr. Michael Lutz Berger, Fraunhofer Institute, Dresden, Germany, 12. 12. - 14. 12. 2007

Visiting Researchers

1. Dr. Marco Peiteado Lopez, Instituto de Ceramica y Vidrio, Madrid, Spain, 1. 10. 2005-31. 12. 2007
2. Dr. Svetoslav Mihaylov Kolev, Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria, 1. 9. 2006 - 31. 8. 2007
3. Dr. Qin Ni, Zhejiang University, Hangzhou, China, 1. 12. 2006 - 31. 12. 2007
4. Dr. Olivier Noguera, Faculte des Sciences et Techniques, UMR-CNRS, Limoges, France, 1. 11. 2007 - 1. 11. 2008
5. Prof. Maria A. Zaghete, Chemistry Institute Araraquara, University of Sao Paulo State, Araraquara, Brasil, 1. 9. 2007 - 31. 12. 2007

STAFF

Researchers

1. Prof. Mihael Drofenik*
2. Dr. Boštjan Jančar
3. Asst. Prof. Darja Lisjak
4. Dr. Marjeta Maček Kržmanc
5. Asst. Prof. Darko Makovec
6. **Prof. Danilo Suvorov****, **Head**
7. Dr. Srečo Davor Škapin
8. Dr. Igor Zajc

Postdoctoral associates

9. Asst. Prof. Irena Ban*
10. Dr. Uroš Kunaver***
11. Dr. Špela Kunej
12. *Dr. Marko Udovič, left 15.10. 2007*

Postgraduates

13. Ines Bračko, B. Sc.
14. Stanislav Čampelj, B. Sc.

15. Urban Došler, B. Sc.
16. Sašo Gyergyek, B. Sc.
17. Jakob Koenig, B. Sc.
18. Slavko Kralj, B. Sc.
19. Manca Logar, B. Sc.
20. Simona Ovtar, B. Sc.
21. Urša Pirnat, B. Sc.
22. Darinka Primc, B. Sc.
23. Matjaž Spreitzer, B. Sc.
24. Asja Veber, B. Sc.
25. Mojca Žnidaršič, B. Sc.

Technical and administrative staff

26. Maja Šimaga Saje, B. Sc.
27. Silvo Zupančič

External researchers

28. Jana Bezjak, B. Sc.***

* Full-time faculty member

** Part-time faculty member

*** Member of industrial or other organisation

DEPARTMENT OF BIOCHEMISTRY, MOLECULAR AND STRUCTURAL BIOLOGY B-1

The research activities of the members of the department are focused on studies of the properties and structure of different proteins, the mechanism of their action and regulation, as well as their physiological role in normal and pathological conditions. The main investigated proteins are proteases and their protein inhibitors.



Head:
Prof. Boris Turk

Proteases as primarily protein-processing enzymes are extremely important signalling molecules involved in numerous vital processes including apoptosis and cell cycle. Their enzyme activities are precisely regulated by several means, including zymogen activation and by their endogenous protein inhibitors. Any imbalance in their regulation can be responsible for pathologies such as cancer, osteoporosis, rheumatoid arthritis, cardiovascular and neurological disorders.

Cysteine cathepsins represent an emerging group of targets for several diseases. Therefore, the development of their inhibitors is of crucial importance. Proteases are synthesized as precursor proteins – zymogens. Zymogen activation is one of the most crucial steps in the regulation of protease activity, during which the proregion has to be removed. We demonstrated that polyanionic polysaccharides and glycosaminoglycans (GAGs) such as naturally occurring chondroitin sulphate and heparin accelerate autocatalytic removal of the propeptide and subsequently activate cathepsin B. The fact that procathepsin B and GAGs often colocalize *in vivo* suggests that GAGs may play a physiological role in the activation of procathepsin B and possibly other cathepsins. It was also shown that propeptide of lysosomal dipeptidase controls enzyme dimerization as well as enzyme activation. Proteolytic degradation of elastic fibers is associated with pathologies such as atherosclerosis and pulmonary emphysema where cysteine cathepsins L, S and K may play an important role. The elastolytic activities of the three cathepsins showed differences in preference for elastins and could be blocked by protein inhibitors cystatins. In addition, it was found that the lack of cathepsin L is responsible for progressive dilated cardiomyopathy in mice.

The most investigated cysteine cathepsin inhibitor is cystatin C. It was suggested that cystatin C may serve as a reliable marker of glomerular filtration in kidney dysfunction. We found that cystatin C may serve also as a potential marker for relapse in patients with non-Hodgkin B cell lymphoma. Another inhibitor, stefin B, serves as a suitable model to study the conversion of a globular protein into amyloid fibrils. We found that the fibrils obtained at pH 3.3 and 4.8 differ, and those at pH 3.3 do not transform to mature fibrils. The domain swapping mechanism was proposed for the fibril formation, suggesting that two domain-swapped dimers of stefin B form tetramers by a previously unknown process, termed “hand shaking”. This occurs concurrently with *trans* to *cis* isomerization of Pro74. This proline residue is highly conserved throughout the cystatin superfamily of inhibitors. Human cystatin C is the key protein in hereditary cerebral amyloid angiopathy. Our findings further contribute to the hypothesis that proline isomerization can play a decisive role in amyloidogenesis.

Caspases, another family of cysteine proteases, play a central role in apoptosis. It was already reported that Fas/CD95 is one of the best characterized receptors from the TNF receptor family with a major role in induction of the *extrinsic* pathway of apoptosis. Our results suggest that cysteine cathepsins have no active role in Fas/CD95 apoptosis, although Bid cleavage was found to be diminished in cathepsin B-deficient cells. We also investigated the *intrinsic* pathway of apoptosis at various stages of maturation in CD-1 mice triggered by two mitochondrial proapoptotic proteins, cytochrome c and SMAC/DIABLO. The obtained results indicated that the activation of the *intrinsic* pathway of apoptosis undergoes a marked shift during postnatal maturation. We also found that MAGI-1, a member of the MAGUK family of proteins is cleaved by caspases-3 and -7 into two fragments, a step which seems to be very important in the disassembly of cell-cell contacts during apoptosis.

Most recently we entered into the field of proteomics with the ultimate goal of analyzing the functional regulation of investigated proteins of our interest. Proteomics is an advanced technology and specifically this area of research has flourished with mass spectrometry. We established a complete proteomics laboratory and the first experiments were performed.

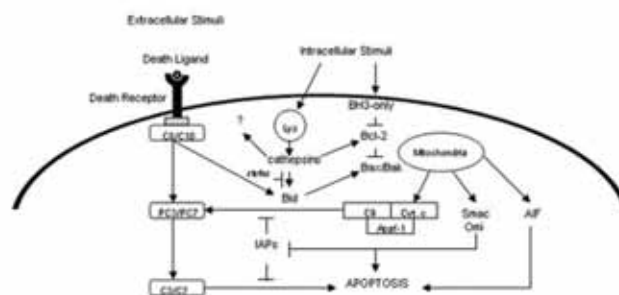


Figure 1: Protease signalling in apoptosis.

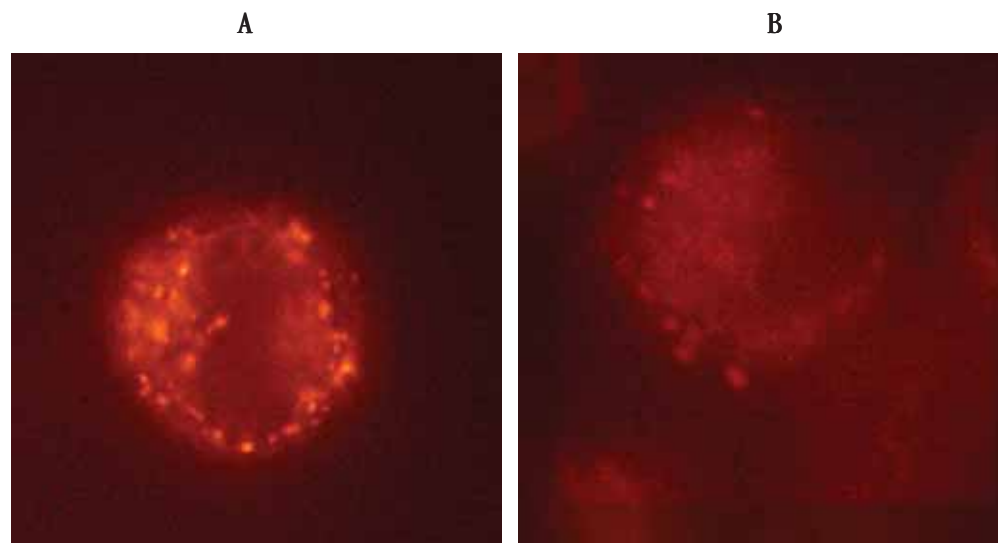


Figure 2. Specific in-vivo cathepsin S activity can be observed in panel A showing a lysosomal-compatible staining in a human macrophage-like cell after incubation with a fluorescent activity-based probe (produced by Sanofi-Aventis partner). Almost no fluorescence can be observed in panel B, where the cells were pretreated with E-64d, a cell-permeable inhibitor of cysteine cathepsins.

We participate in four EU projects within the EU's FP6, and one project in FP7 was already approved. We also participate in the highly prestigious project within the Human Science Frontiers Program (HSFP), for the first time given to a Slovenian research group jointly with the groups at the University of Tokyo, Stanford University and the Burnham Institute for Medical Research (San Diego). In addition, there are many other international collaborations with many high-quality research teams from different countries such as Germany, USA, Australia, Japan and others, which resulted in joint publications. Several members of the group were invited to give lectures at international symposia and foreign universities.

Some outstanding publications in the past three years

1. Turk B., Turk D. and Salvesen G.S. (2005) Regulating cysteine protease activity: Essential role of protease inhibitors as guardians and regulators. *Medicinal Chem. Rev.-Online* 2, 283-297
2. Turk B. (2006) Targeting proteases: successes, failures and future prospects. *Nature Reviews Drug Discovery* 5, 785-799.
3. Jenko Kokalj S., Gunčar G., Štern I., Morgan G., Rabzelj S., Kenig M., Staniforth R.A., Waltho J.P., Žerovnik E. and Turk D. (2007) Essential role of proline isomerization in stefin B tetramer formation. *J Mol Biol.* 366:1569-1579.
4. Novinec M., Grass R.N., Stark W.J., Turk V., Baici A. and Lenarčič B. (2007) Interaction between human cathepsins K, L, and S and elastins: mechanism of elastinolysis and inhibition by macromolecular inhibitors. *J. Biol. Chem.* 282:7893-7902.
5. Caglič D., Rozman Pungercar J., Pejler G., Turk V. and Turk B. (2007) Glycosaminoglycans facilitate procathepsin B activation through disruption of propeptide-mature enzyme interactions. *J. Biol Chem.* 282 :33076-33085.
6. Vasiljeva O., Reinheckel T., Peters C., Turk D., Turk V. and Turk B. (2007) Emerging roles of cysteine cathepsins in disease and their potential as drug targets. *Curr. Pharm. Des.* 13:387-403.
7. Turk B. and Stoka V. (2007) Protease signalling in cell death: caspases versus cysteine cathepsins. *FEBS Lett.* 581: 2761-2767.

Organization of conferences, congresses and meetings

1. 24th Winter School on Proteinases and their Inhibitors, Recent Developments, Tiers, Italy, 128. 2. - 4. 3. 2007 (coorganisers)
2. Xth International Symposium on Proteinase Inhibitors and Biological Control-From single molecules to degradomics-Portoroz, Slovenia, June 23 - 27, 2007
3. 15th ECDO Euroconference on Apoptosis, Portorož, Slovenia, 26. - 31. 10. 2007 (organisers)

Awards and appointments

1. Vito Turk, Honorary member of the Slovene Biochemical Society
2. Tomaž Langerholc, Krka Award for PhD thesis
3. Boris Turk, member of European Molecular Biology Organisation (EMBO)
4. Boris Turk, Secretary General of European Cell Death Organisation (ECDO)

BIBLIOGRAPHY

ORIGINAL ARTICLES

- Lea Bojić, Ana Petelin, Veronika Stoka, Thomas Reinheckel, Christoph Peters, Vito Turk, Boris Turk
Cysteine cathepsins are not involved in Fas/CD95 signalling in primary skin fibroblasts
In: FEBS lett., Vol. 581, pp. 5185-5190, 2007.
- Dejan Čaglič, Jerica Rozman Pungercar, Gunnar Pejler, Vito Turk, Boris Turk
Glycosaminoglycans facilitate procathepsin B activation through disruption of propeptide-mature enzyme interactions
In: J. biol. chem., Vol. 282, pp. 33076-33084, [in press] 2007.
- Iztok Dolenc, Roger H. Pain, Vito Turk
Presence of the propeptide on recombinant lysosomal dipeptidase controls both activation and dimerization
In: Biol. chem. (Print), Vol. 388, pp. 47-51, 2007.
- Marko Fonović, Matthew Bogoy
Activity based probes for proteases: applications to biomarker discovery, molecular imaging and drug screening
In: Curr. pharm. des., Vol. 13, no. 3, pp. 253-261, 2007.
- Marko Fonović, Steven H. L. Verhelst, M. T. Sorum, Matthew Bogoy
Proteomics evaluation of chemically cleavable activity-based probes
In: Molecular & cellular proteomics, Vol. 6, no. 10, pp. 1761-1770, 2007.
- Jade K. Forwood, Anil S. Thakur, Gregor Gunčar, Mary Marfori, Dmitri Mouradov, Weining Meng, Jodie Robinson, Thomas Huber, Stuart Kellie, Jennifer L. Martin, David A. Hume, Boštjan Kobe
Structural basis for recruitment of tandem hotdog domains in acyl-CoA thioesterase 7 and its role in inflammation
In: Proc. Natl. Acad. Sci. U. S. A., Vol. 104, no. 25, pp. 10382-10387, 2007.
- Uroš Gregorc, Saška Ivanova, Miranda Thomas, Ernesto Guccione, Britt Glaunsinger, Ron Javier, Vito Turk, Lawrence Banks, Boris Turk
Cleavage of MAGI-1, a tight junction PDZ protein, by caspases is an important step for cell-cell detachment in apoptosis
In: Apoptosis, Vol. 12, no. 2, pp. 343-354, 2007.
- Gregor Gunčar, Ching-I. A. Wang, Jade K. Forwood, Trazel Teh, Ann-Maree Catanzariti, Jeffrey G. Ellis, Peter N. Dodds, Boštjan Kobe
The use of Co²⁺ crystallization and structure determination, using a conventional monochromatic x-ray source, of flax rust avirulence protein
In: Acta crystallographica. Section F, Structural biology and crystallization communications, Vol. 63, pp. 209-213, 2007.
- Saška Ivanova, Urška Repnik, Lawrence Banks, Vito Turk, Boris Turk
Cellular localization of MAGI-1 caspase cleavage products and their role in apoptosis
In: Biol. chem. (Print), Vol. 388, pp. 1195-1198, 2007.
- Saša Jenko, Gregor Gunčar, Igor Stern, Gareth J. Morgan, Sabina Rabzelj, Manca Kenig, Rosemary A. Staniforth, Jonathan P. Waltho, Eva Žerovnik, Dušan Turk
Essential role of proline isomerization in stefin B tetramer formation
In: J. Mol. Biol., Vol. 366, pp. 1569-1579, 2007.
- Nataša Kopitar-Jerala, Boris Turk
Cleavage of the myristoylated alanine-rich C kinase substrate (MARCKS) by cysteine cathepsins in cells and tissues of stefin B-deficient mice
In: Biol. chem. (Print), Vol. 388, pp. 847-852, 2007.
- Marko Mihelič, Dušan Turk
Two decades of thyroglobulin type-1 domain research
In: Biol. chem. (Print), Vol. 388, pp. 1123-1130, 2007.
- Adaleta Mulaomerović, Alma Halibašić, Elmir Čičkušić, Tina Zavašnik-Bergant, Lejla Begić, Janko Kos
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THESES

Ph. D. Theses

1. Lea Bojić: Molecular mechanisms of apoptosis triggered by lysosomal proteases, (Boris Turk)
2. Dejan Čaglič: The role of lysosomal cysteine cathepsins in human chondrocyte cell lines (Boris Turk)
3. Saška Ivanova: Proteins from the DLG, ZO and MAGI subfamilies as substrates for cellular proteases during apoptosis (Boris Turk)
4. Tomaž Langerholc: Expression and characterization of cystatin F and its role in antigen presentation (Boris Turk)

5. Marko Mihelič: Interaction of mouse and human cathepsins L and S with the inhibitory fragment of MHC class II associated p41 form of invariant chain (Dušan Turk)
6. Miha Pavšič: The role of thyroglobulin type-1 modules in regulation of activity of proteases (Brigita Lenarčič)

B. Sc. Theses

1. Ana Bombač: Involvement of cysteine cathepsins in apoptosis in SH-SY5Y neuroblastoma and T89G glioblastoma cell lines (Vito Turk)
2. Jožef Molek: Identification of caspases cleavage sites in protein DLG1 (Vito Turk)
3. Nina Vidergar: Retroviral transduction for generation of stable cell lines which express Cln genes (Vito Turk)

INTERNATIONAL PROJECTS

1. Chemical Genomics by Activity Monitoring of Proteases
6. FP, CAMP
LSHG-CT-2006-018830
EC; Dr. Manuel Morillas, Universitat Autònoma de Barcelona, Institut de Biotecnologia i de Biomedicina (IBB), Bellaterra (Cerdanyola del Vallès), Spain
Prof. Boris Turk
2. High Throughput Development of Drugs for Immunotherapy of (Auto) immune Diseases Drugs for Therapy
6. FP, MRTW-CT-2004-512385
EC; Prof. Frits Koning, Leiden University Medical Center, Leiden, The Netherlands
Prof. Dušan Turk
3. Safe Production and Use of Nanomaterials
NANOSAFE2, 6. FP
NMP2-CT-2005-515843
EC; Commissariat à l'Énergie Atomique, Grenoble, France
Prof. Boris Turk, Asst. Prof. Maja Remškar, Marko Žumer, B. Sc., Andrej Detela, B. Sc.
4. Intracellular Protease Signaling induced by Homopolymeric Amino Acid (HPAA) Tracts
RG105, 0024/2006-C
International Human Frontier Science Program Organisation, Strasbourg, France
Prof. Boris Turk
5. FEBS Fellowship for Dr. Zoran Štefanić
FEBS - Federation of European Biochemical Societies, Prof. Maciej Nalecz, UNESCO, SB/BES, B3.29, Paris, France
Prof. Dušan Turk
6. Proteolytic Activities in Trypanosoma Cruzi: Cruzipain, Metacaspase, Serine Carboxypeptidase
BI-AR/06-08-03
Prof. Juan Jose Cazzulo, Instituto de Investigaciones Biotecnológicas, Instituto Tecnológico de Chascomus, Universidad Nacional de General San Martín- CONICET, San Martín, Provincia de Buenos Aires, Argentina
Prof. Vito Turk
7. Izabrane tačkaste mutacije aromata u čovječijim stefinima A i B. Uticaj na stabilnost, dimerizaciju i svijanje proteina
Chosen Site-mutations of Aromatic Amino Acids in Human Stefins A and B. Influence on Dimerization, Folding and Aggregation
BI-BIH/05-06-001
Prof. Selma Berbić, Farmaceutvska fakulteta, Univerza v Tuzli, Tuzla, Bosnia and Herzegovina
Asst. Prof. Eva Žerovnik
8. Izabrane tačkaste mutacije aromata u čovječijim stefinima A i B. Uticaj na stabilnost, dimerizaciju i svijanje proteina

- BI-BIH/06-08/001
Prof. Selma Berbić, Medicinski fakultet, Univerza v Tuzli, Tuzla, Bosnia and Herzegovina
Asst. Prof. Eva Žerovnik
9. The influence of tick saliva cystatin on the functioning of human dendritic cells
BI-CZ/07-08-020
Prof. Libor Grubbhofer, Faculty of Biological Sciences, University of South Bohemia, České Budejovice, Czech Republic
Dr. Tina Zavašnik Bergant
 10. Mechanisms of Apoptosis and Aging as Revealed by Yeast and Mammalian Cell Models
BI-IN/06-07-011
Prof. Roy Nilanjan, National Institute of Pharmaceutical Education and Research (NIPER), Punjab, India
Asst. Prof. Eva Žerovnik

R & D GRANTS AND CONTRACTS

1. The effect of citrullination of extracellular matrix proteins to degradation by cysteine and metalloproteases in arthritic joints
Prof. Dr. Boris Turk
2. The role of cysteine proteinases and their inhibitors in endotoxin tolerance
Dr. Nataša Kopitar Jerala
3. Cathepsin F, a novel cysteine protease involved in neuronal ceroid lipofuscinosis
Asst. Prof. Veronika Štoka
4. Role of cysteine cathepsins as immunomodulators in rheumatoid arthritis
Prof. Dr. Boris Turk, Dr. Urška Repnik

RESEARCH PROGRAMS

1. Structural Biology
Prof. Dr. Dušan Turk
2. Proteolysis and its regulation
Prof. Dr. Vito Turk

NEW CONTRACT

1. Hybridoma cell line development
Lek farmacevtska družba d.d.
Asst. Prof. Aleš Premžl

VISITORS FROM ABROAD

1. Dušana Majera, Bački Petrovac, Serbia, 01.01.do 31.12.2007, (Stipendist Marie Curie Actions: Research Training Network)
2. prof. dr. Ana Marušić, Department of Physiology and Immunology, University School of Medicine, Zagreb, 2. 2. 2007
3. prof. dr. Danka Grčević, Department of Physiology and Immunology, University School of Medicine, Zagreb, Croatia, 2. 2. 2007
4. dr. Veronique Vandevoorde, ECDO, Brussels, Belgium, 21. 4. 2007
5. mag. Aida Kriještorac, University of Tuzla, Faculty of Pharmacy, Tuzla, Bosnia and Herzegovina, 3.06. do 2.07.2007 in 03.09. do 15.10.2007 (Scientific research cooperation)
6. prof. dr. George L. Kenyon, College of Pharmacy, University of Michigan, USA, 18.6.2007

7. prof. dr. Nobuhiko Katunuma, Tokushima Bunri University, Institute for Health Sciences, Tokushima, Japan, 21.09. do 22.09.2007
8. Zoran Štefanić, Ruder Bošković Institute, Physical Chemistry - Laboratory for Chemical and Biological Crystallization, Zagreb, Croatia, 01.10. - 31.12.2007
9. prof. dr. Selma Berbić, University of Tuzla, Medical Faculty, Bosnia and Herzegovina 1.10. do 15.10.2007
10. prof. dr. Mauro Piacentini, University of Rome "Tor Vergata", Rome 27. 09. 2007
11. prof. dr. David Huang, prof.dr. Zahra Zakeri and prof.dr. Richard Lockshin, 25. 10. 2007
12. prof. dr. Gerd Multhaup, Institute of Chemistry, Free University Berlin, Germany, and prof.dr. Robert Layfield, School of Biomedical Sciences, University of Nottingham, UK, 5. - 7. 10. 2007
13. prof.dr.Selma Kanazir, University of Belgrade, prof.dr. Marko Živin, University of Ljubljana, Medical Faculty, Serbia, 6. 12. 2007

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16. Dr. Kristina Orešič
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18. Dr. Urška Repnik
19. *Dr. Jerica Rozman Pungerčar, left 1. 5. 2007*
20. *Dr. Igor Stern, left 1. 11. 2007*
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28. Martina Klarič, B. Sc.
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35. Jure Praznikar, B. Sc.
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37. Miha Renko, B. Sc.
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* Full-time faculty member

** Part-time faculty member

DEPARTMENT OF MOLECULAR AND BIOMEDICAL SCIENCES B-2

The research programme of the Department of Molecular and Biomedical Sciences is focused mainly on basic research in protein biochemistry, molecular and cellular biology, and genetics. The primary goal of our investigations is a new understanding of mammalian (patho)physiology, with the aim of improving human and animal health.



Head:
Prof. Igor Krizaj

Secreted phospholipases A₂ (sPLA₂s)

The major research topic of the department is secreted phospholipases A₂ (sPLA₂s), both those from animal toxins and those endogenous to humans. We are interested in the molecular mechanisms of the action of toxic sPLA₂s, particularly those with presynaptic neurotoxicity, anticoagulant activity and myotoxicity, as well as in the roles of endogenous sPLA₂s in the pathological and physiological processes in mammals.

One of the characteristic pathologic effects of neurotoxic sPLA₂s is their damage to mitochondria. Following the discovery of endogenous sPLA₂ in the mitochondria of neuronal cells and the colocalization of the fluorescently labelled ammodytoxin A (AtxA), a model neurotoxic sPLA₂ from the venom of the long-nosed viper (*Vipera a. ammodytes*), with mitochondria in the PC12 cell line, we focused in the past year on the characterization of the influence of AtxA on mitochondria in this cell line. We followed the formation of free radicals and the changes to the mitochondrial membrane potential in differentiated and non-differentiated PC12 cells after they were exposed to AtxA or some other sPLA₂. We also measured these parameters on isolated mitochondria. Some of the studies were performed in the scope of a bilateral project in collaboration with the University of Perugia.

In the past year we arranged and analyzed the results of the study of the molecular mechanism of action of AtxA on mouse and rat neuromuscular preparations *ex vivo* (Figure 1), obtained in the trilateral NATO Collaborative Linkage Grant collaboration with Newcastle University and the University of Strathclyde in Glasgow. One of the most important riddles to solve in order to reveal the molecular basis of the action of the presynaptically toxic sPLA₂s is to structurally identify their specific receptor on the presynaptic membrane of a motoneuron. Using the radioactive derivative of AtxC, a natural isoform of AtxA, the N-type receptors, tentatively the key receptors for expressing the neurotoxicity of sPLA₂s, could not be detected in the rat's brain. However, similar receptors were found in the electric organ (modified peripheral nerve system) of *Torpedo marmorata* and we started to develop the isolation procedure from this tissue. We also looked for specific Atx receptors in lipid rafts, but until now we have not found any new receptors. It is known that receptors for natural neurotoxins are not exclusively of a protein nature; they can also be glycolipids. From presynaptic membranes of the porcine cerebral cortex we isolated the glycolipid fraction and evaluated the interaction of Atx with this fraction. The interaction of Atx with glycolipids was also studied on artificial vesicles prepared from the pure (glyco)lipid components in known ratios. In collaboration with the Institute of Biochemistry from the Medical Faculty, University of Ljubljana, we continued with the study of the influence of Atx on the G-protein-coupled receptors in rat-brain neurons. At present, the activation of G-proteins can be neither confirmed nor ruled out.

To advance the study of sPLA₂, the development of new molecular tools is necessary. For this purpose we constructed an original photo-reactive derivative of AtxC, sulfo-SBED-AtxC. Its preparation, characterization and use we described in the paper [COBISS.SHD 20950823]. Using this derivative we discovered two novel neuronal binding proteins for Atx, developed a more effective procedure to isolate R25, which is the Atx receptor in neuronal mitochondria, and studied the topology of interactions between Atx and its known binding proteins, calmodulin (CaM), protein disulphide isomerase, 14-3-3 proteins and the

New substances and molecular tools to improve human and animal health.

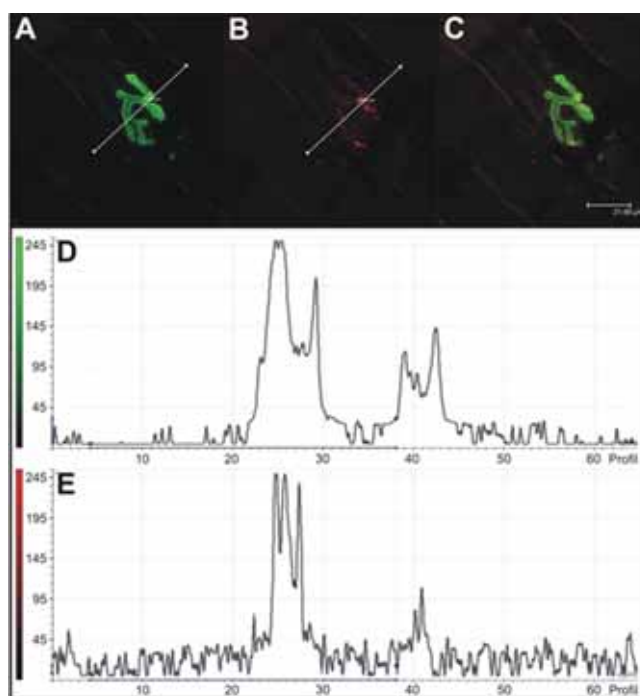


Figure 1: Longitudinal section of a mouse soleus muscle exposed to Alexa⁵⁴⁶-conjugated AtxA revealed a perisynaptic localization of the toxin derivative. The red fluorescence signal belongs to the Alexa-conjugated toxin, while the AChR (postsynaptic localization) were counter-labelled with green fluorescence using FITC-conjugated cèbungarotoxin.

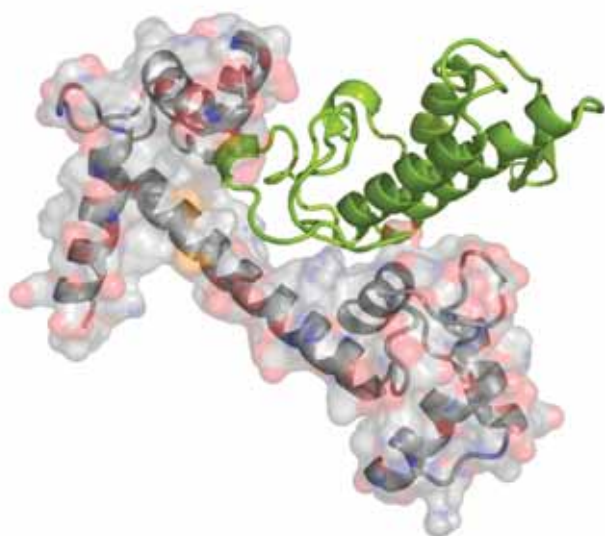


Figure 2: The tridimensional model of the complex between AtxA (green) and CaM.

activated blood-coagulation factor X (FXa). Based on these studies we built a model of the Atx-CaM complex (Figure 2). On a mouse motoneuronal cell line and using sulfo-SBED-AtxC we unambiguously demonstrated, for the first time, that the sPLA₂ was translocated into the cytosol of a eukaryotic cell (publication submitted). We demonstrated that the internalization of the Atx into neuronal cells is highly dependent on the presence of calcium (Ca²⁺) ions in the extracellular space. In the absence of Ca²⁺, the neurotoxin was still internalized, but to a much lesser extent. Ca²⁺ ions are important for the enzymatic activity of Atx, which is essential for its neurotoxicity. After the internalization of Atx into the model mouse motoneurons, we observed a significant reduction in the staining intensity for two synaptic vesicle proteins, synaptophysin and synaptotagmin, as well as a reorganization of the F-actin cytoskeleton. Atx also induced the cell death of motoneurons, probably through the mitochondrial pathway, which we still have to investigate in detail. By using fluorescently labelled Atx and antibodies to clathrin, we showed that Atx internalized largely by clathrin-mediated endocytosis, although other pathways, such as through synaptic vesicles, could not be excluded. The toxin uptake was efficiently suppressed by the addition of a nontoxic and enzymatically active sPLA₂, ammodytin I₂, indicating the presence of specific receptors on the surface of motoneuronal cells involved in the internalization. Based on the results obtained, we conclude that Atx, following the internalization into the neuronal cell (Figure

3), undergoes intracellular trafficking to different organelles and, to some extent, also into the cytosol. Until now we have not been able to clearly demonstrate the presence of similar or identical receptors on the presynaptic membrane of the neuro-muscular junction of the victim of a snake bite and on the model motoneurons.

Aiming to develop a method for the targeted therapy of cancer, we prepared the conjugate between sulfo-SBED-AtxC and “targeting” antibodies that specifically recognized CaCo-2 cancer cells and internalized the toxin into these cells [COBISS.SI-ID 21313831].

Collaborating in a bilateral project, we succeeded together with our colleagues from the Institute Pasteur in Paris to crystallize AtxA, its N-terminal fusion mutant and AtxC and determine their tridimensional structures. In the past year we also continued to search for conditions to crystallize AtxA in a complex with FXa. The purpose of these studies is to develop innovative anticoagulant drugs on the basis of the structure of AtxA that is interacting with FXa. We also continued with the cocrystallization of AtxA and its cytosolic target protein CaM. We proved that concentrations of Ca²⁺ present in the cytosol of eukaryotic cells support the interaction between Atx and CaM (publication submitted), an additional argument in favour of our hypothesis about the intracellular action of presynaptically neurotoxic sPLA₂s, which we described in detail in the invited review paper [COBISS.SI-ID 21173543].

Related to this hypothesis, the observation that the enzymatic activity of Atx increases substantially when it is in a complex with CaM is very interesting. Kinetic studies of the activation of enzyme activity of Atx and some other sPLA₂s in the presence of CaM are underway.

In this year we concluded an extensive study on the action of enzymatically inactive myotoxic phospholipases using ammodytin L (AtnL), a group IIA sPLA₂ homologue, as a model [COBISS.SI-ID 21167399]. A characteristic of these myotoxins is that the Asp-49 residue in the so-called “calcium binding loop” is usually substituted with a Lys or rarely with a Ser residue. AtnL is one of the two known Ser-49 homologues. In addition to this replacement, several other substitutions can be found in the molecules of enzymatically inactive snake sPLA₂s in the region of the Ca²⁺ binding loop that is involved in the coordinative binding of a cofactor, Ca²⁺ ion, essential for the catalytic activity of sPLA₂ enzymes. By site-directed mutagenesis, we prepared two enzymatically active quaternary mutants of AtnL (H28Y/L31V,W/N33G/S49D), differing at position 31. The LV-mutant possessed Val, while the LW-mutant had Trp at this place. Both mutants, in contrast to the recombinant wild-type AtnL, efficiently hydrolyzed phospholipid vesicles of different compositions, as expected, LW-mutant being approximately 50-fold more active than the LV-mutant. In contrast to AtnL, but similarly to AtxA, a homologous neurotoxic sPLA₂, both mutants exhibited enzyme-activity-dependent membrane damage. However, both mutants also exhibited the

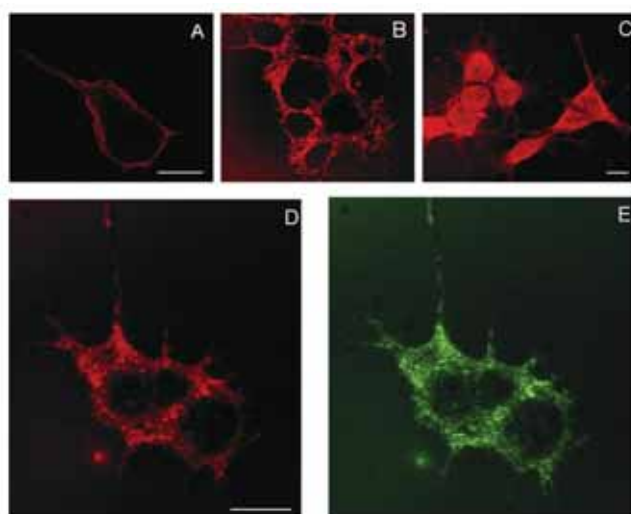


Figure 3: Time course of the internalization of fluorescently labelled AtxA(N79C)-Texas Red into the cells of a motoneuronal line (A, after 2 min; B, D and E, after 15 min; C, after 60 min; E, fluorescently labelled AtxA in the cell, additionally stained by specific antibodies to AtxA (green)).

potent Ca^{2+} -independent disruption of vesicle integrity, a characteristic of AtnL, but not of AtxA. Although the LV and, especially, the LW-mutant display higher cytotoxicity and higher lethal potency, they have a lower Ca^{2+} -independent membrane-damaging potency and reduced specificity in targeting muscle fibres *in vitro* than AtnL. Our results indicate that during evolution the Lys-49 and Ser-49 sPLA₂ myotoxins have lost their Ca^{2+} -binding ability and enzymatic activity through subtle changes in the Ca^{2+} -binding network. At the same time, the rest of the catalytic machinery has not been affected, thereby optimizing their Ca^{2+} -independent membrane-damaging ability and myotoxic activity.

In the scope of a bilateral project with the Institute of Immunology in Zagreb and in collaboration with the Bia Separations company from Ljubljana we developed a rapid chromatographic method for an accurate determination of the Atx content in venoms of *Vipera a. ammodytes* specimens [COBISS.SI-ID 21233959]. A high correlation was found between the content of Atx in the venom and the suitability of the venom for the preparation of high-quality antiserum by animal immunization. Our findings will lower the price of high-quality antiserum production and reduce the work on animals in the process of their preparation.

Studying the role of endogenous sPLA₂s in physiological and pathological processes in mammals we designed oligonucleotide primers and optimized the PCR conditions for the amplification of the mRNA of the four enzymatically most active sPLA₂ groups in mouse, rat and human. In addition, we prepared several plasmid constructs to investigate the roles of human endogenous sPLA₂s in cancer diseases and began with the culturing of cell lines of breast-cancer origin.

The research on sPLA₂ inhibitors is conveyed in the first place, aiming to discover new molecules to control the activity of endogenous as well as exogenous sPLA₂. In 2007 we finalized the characterization of the sPLA₂ inhibitor from the serum of *Vipera a. ammodytes* and published the results [COBISS.SI-ID 21233703].

Other pharmacologically active components from natural toxins

In 2007 we continued with our research on the *Vipera a. ammodytes* venom components that affect hemostasis. In particular we focused on the biochemical and pharmacological characterization of hemorrhagic and nonhemorrhagic metalloproteinases (MP). The description of fibrinolytic ammodytase with a high application potential for the therapy of thromboses was published [COBISS.SI-ID 20706855]. We also prepared an application for a project, the goal of which is to develop the ammodytase towards its medical use. We tested the influence of this snake venom MP on epithelial cells. With the development of specific antibodies against the most toxic components of the *Vipera a. ammodytes* venom we continued, together with the Institute of Immunology in Zagreb, the work on preparing safer antisera for the treatment of envenomed patients. In addition to neurotoxic Atx these are also hemorrhagic MP. The produced antibodies have also been successfully used in purification procedures as well as during further characterization of these venom components.

This year we started work on the EU 6FP integrated project "Conco". As one of the 20 partners we have been involved in the analysis of genome and venom proteome of the venomous fish-hunting cone snail *Conus consors*, the preparation of the synthetic polypeptide venom library and pharmacological screening, aiming at discovery of drug leads to develop new biological drugs.

Phenomics in yeast *Saccharomyces cerevisiae*

We have developed an experimental method and the underlying bioinformatics tools for a quantitative determination of the growth rates of yeast strains with agar-based assay; this enables a high-throughput chemical genomics analysis. In combination with genetic interaction data, this approach, named "context-dependent genetic interaction analysis", enables the identification of drug targets, the mechanisms of the action of small molecules or proteins, and gene function (Figure 4).

Using this approach we have been studying the cellular responses to different perturbations of membranes and lipid metabolism. We have started identifying the genes that build a core network that regulates lipid and membrane homeostasis in eukaryotic cells.

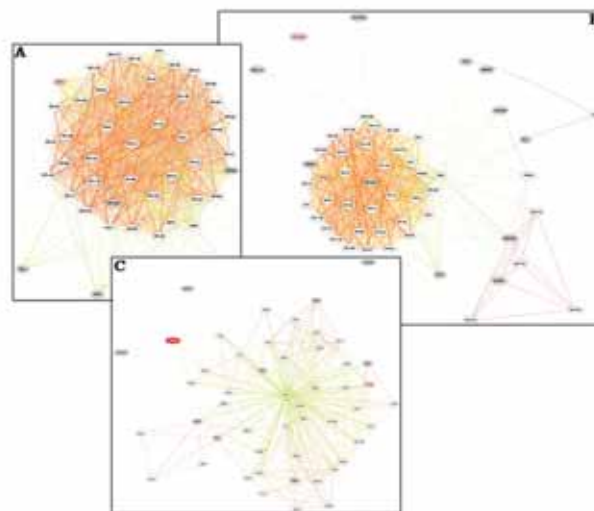


Figure 4: Context-dependent genetic interaction analysis. Three networks of interactions between functionally related yeast genes, determined through genetic interactions with a studied gene, and identifying the function of the studied gene under three different conditions (A, B and C, respectively).

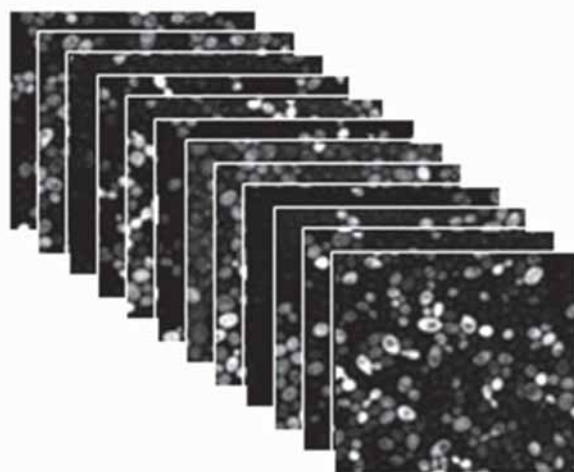


Figure 5: Images of 12 identified strains, out of a total of 4800 tested, with aberrant peroxisome biogenesis.

In collaboration with the University of Graz, Austria, we have developed a high-throughput method for the analysis of organelle biology (biosynthesis, inheritance, proliferation and degradation) in the context of all yeast single-gene deletion yeast strains (Figure 5).

We have rigorously shown that the combination of gene expression and genetic interaction data can be used to accurately predict the mechanism of action of pharmacologically active substances (publication submitted). In collaboration with the Faculty of Computer and Information Sciences of the University of Ljubljana, we have developed a computational method for the implementation of this discovery (Figure 6).

In collaboration with the University of Pavia we have developed a methodology for learning gene-regulatory networks from DNA microarray data based on the integration of different data and knowledge sources. We applied the method to *S. cerevisiae* experiments, focusing our attention on cell-cycle regulatory mechanisms, and biologically evaluated it on known cell-cycle genes against independent knowledge sources [COBISS.SI-ID 21202727].

Evolutionary genomics of transposable elements and functional studies of retrotransposons

We continued our research on the eukaryotic transposable elements. Analyses of diverse eukaryotic genome databases provided the answers to numerous interesting questions. The genome architectures of mammals and birds are quite unusual, since they have lost the diversity of transposable elements, but the remaining transposable elements reached very high copy numbers and have reshaped these genomes. Until now it was not known when and why such huge changes occurred. The answers are hidden in the genomes of land vertebrates and especially in those of reptiles. In the genomes of the lizard (*Anolis carolinensis*), crocodiles and turtles we analyzed numerous

retroelements and DNA transposons. Very large retroelement diversity was discovered in the lizard genome, but not in the genomes of crocodiles and turtles. With the help of the palaeogenomic analysis of transposable elements in diverse reptilian groups and a planetary-biological approach we found the answer to the long-standing question of why mammalian and avian genomes are so different and unique among the metazoans. In the genome of the lizard (*Anolis carolinensis*) we analyzed the L1 retrotransposons, and discovered an enormous L1 diversity, which is currently the highest among the vertebrates. We found more than 150 diverse L1 families; the copy numbers of L1s per family are very variable. This discovery is very important, since it provides direct evidence that the L1 repertoire in the genome of the mammalian ancestor was also very rich. Fungi, our closest opisthokont relatives, and the metazoans possess very different transposable element contents. Until now it was not explained when and how the metazoan-specific transposable element groups originated. We analyzed the transposable elements in the genomes of the most ancestral metazoan lineages, in sponges and cnidarians. We found that the majority of the metazoan-specific transposable element groups originated very early in the last common ancestor of Metazoa and that some smaller transposable element lineages originated later. These analyses also provided evidence for the enormous diversity of retroelements and DNA transposons in the genomes of sponges and cnidarians that is much higher than in vertebrates. The analyses of DNA transposons and retroelements in the key eukaryotic lineages provided the answer to the crucial question about the origin and

evolution of DNA transposons and retroelements in eukaryotes. By analysing more than 300 eukaryotic genomes we provided the evidence about where and when particular superfamilies of DNA transposons and retroelements originated and also the mechanisms of their evolution. We studied the horizontal gene transfer in mammals, since we are the pioneers in this field, and reported in 1995 the first such example [COBISS.SI-ID 10623015]. The availability of a very large number of mammalian genomes from all three major mammalian lineages has enabled the study of horizontal gene transfer in mammals. We found that horizontal transfer is not limited to the retroelements, and we found a number of new examples of the retroelement horizontal transfers between insects and their predators (insectivores and bats). During the evolution of chromoviruses we found unusual Metaviridae with unique targeting domains (e.g., the PHD domain) and additional ORFs (envelope proteins). The availability of the numerous genomes of the unicellular and basal eukaryotes enabled an analysis of the origin and evolution of the PHD domain and envelope proteins in eukaryotic Metaviridae. We also studied the interactions among the proteins involved in RNA metabolism (P bodies) and the proteins of the LTR (HERV-K) and non-LTR retrotransposons (LINE-1). The colocalization of the proteins, encoded by the LTR and non-LTR retrotransposons, and the APOBEC3 proteins was studied in mammalian cells.

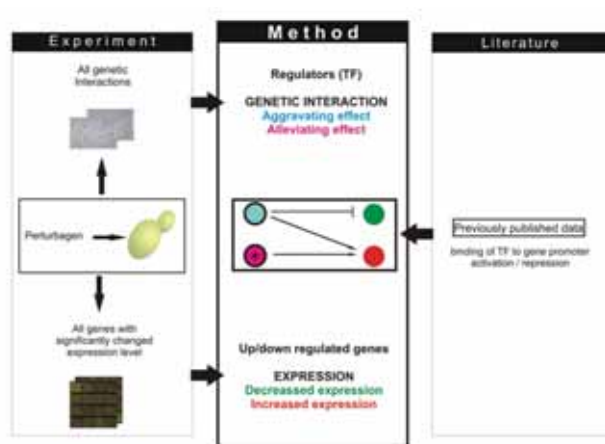


Figure 6: Schematic representation of the method for the prediction of the mechanism of action of pharmacologically active substances based on gene expression and genetic interaction data. Experimental data on the effects of the perturbagen on the transcriptome and on its genetic interactome, together with literature data on the nature of the effect of the regulators in genetic interaction with genes with a significantly changed expression level, are used as input data. The method generates a wiring diagram of a hypothetical model of the molecular mechanism of the action of the perturbagen.

Some outstanding publications in 2007

1. Okeoma, C.M., Lovšin, N., Peterlin, B.M. and Ross, S.R. (2007) APOBEC3 inhibits mouse mammary tumour virus replication in vivo. *Nature* 445, 927–930. [COBISS.SI-ID 20903975]
2. Pungercar, J. and Križaj, I. (2007) Understanding the molecular mechanism underlying the presynaptic toxicity of secreted phospholipases A₂ (review). *Toxicon* 50, 871–892. [COBISS.SI-ID 21173543]
3. Petan, T., Križaj, I. and Pungercar, J. (2007) Restoration of enzymatic activity in a Ser-49 phospholipase A₂ homologue decreases its Ca²⁺-independent membrane damaging activity and increases its toxicity. *Biochemistry* 46, 12795–12809. [COBISS.SI-ID 21167399]
4. Šribar, J., Kovačič, L., Draškovič, P., Faure, G. and Križaj, I. (2007) The first phospholipase inhibitor from the serum of *Vipera ammodytes ammodytes*. *FEBS J.* 274, 6055–6064. [COBISS.SI-ID 21233703]
5. Ferrazzi, F., Magni, P., Sacchi, L., Nuzzo, A., Petrovič, U. and Bellazzi, R. (2007) Inferring gene regulatory networks by integrating static and dynamic data. *Int. J. Med. Inform.* 76, 462–475. [COBISS.SI-ID 21202727]

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Comparison of natural and recombinant cliticypins, the fungal cysteine protease inhibitor. *Protein expr. purif.* 53, 104-111.

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Understanding the molecular mechanism underlying the presynaptic toxicity of secreted phospholipases A₂
In: *Toxicon (Oxford)*, Vol. 50, pp. 871-892, 2007.

B. SC. THESES

1. Mitja Lah: Development of the method for simultaneous isolation of six hemostatically active metalloproteases from the venom of *Vipera a. ammodytes* and their characterization (Igor Križaj).
2. Katjuša Reja Mozetič: Analysis of the molecular mechanisms of action of phenylbutyrate, phenylacetate and nicotine on yeast *Saccharomyces cerevisiae* (Uroš Petrovič).
3. Tanja Martinčič: Preparation and characterisation of a recombinant human group V secretory phospholipase A₂ (Jože Pungercar).
4. Andreja Šmerc: Isolation of caseins from horse milk and development of an electrophoresis system for their separation (Jože Pungercar, Peter Dovč).

INTERNATIONAL PROJECTS

1. Applied Venomics of the Cone Snail Species *Conus* Consors for the Accelerated, Cheaper, Safe and More Ethical Production of Innovative Biomedical Drugs
CONCO
6. FP EC; IP
037592, LSHB-CT-2007-03792
EC; Coordinator: Dr. Reto Stöcklin, Atheris Laboratories, Plan-les-Quates - Geneve, Switzerland
Prof. Igor Križaj
2. Neurotoxic Phospholipases A2 - How They produce the Neuromuscular Blockade and How to prevent it
NATO Programme Security through Science, Collaborative Linkage Grant
PDD(CP)-(EAP.CLG.980899)
NATO Public Diplomacy Division; Dr. Edward G. Rowan, University of Strathclyde, Strathclyde Institute of Biomedical Sciences, Department of Physiology & Pharmacology, Glasgow, Scotland, Great Britain
Prof. Igor Križaj
3. Phospholipases A2 and PEX11 in Fatty Acid Signalling in Yeast
BI-AT/07-08-014
Prof. Sepp D. Kohlwein, University of Graz, Institute of Molecular Biosciences, Graz, Austria
Asst. Prof. Uroš Petrovič
4. Study on the Identification of the Anticoagulant Site of Phospholipases A2 by Biochemical and Crystallographic Approach

- BI-FR/06-PROTEUS-005
Dr. Grazyna Faure, Unité d'Immunologie Structurale, Paris, France
Prof. Igor Križaj
5. Analysis of Immunogenicity of the Long-nosed Viper (*Vipera ammodytes ammodytes*) Venom Components
BI-HR/06-07-008
Dr. Beata Halassy Špoljar, Institute of Immunology, Department for Research and Development, Zagreb, Croatia
Prof. Igor Križaj
 6. The Role of Secreted Phospholipases A2 in Mitochondrial Function and Dysfunction
BI-IT/05-08-021
Gianfrancesco Goracci, Department of Internal Medicine, Division of Biochemistry-University of Perugia, Perugia, Italy
Prof. Igor Križaj

R & D GRANTS AND CONTRACTS

1. Phospholipases in yeast *Saccharomyces cerevisiae*
Prof. Igor Križaj
2. Employment of yeast cell to determine the toxicity of selected neonicotinoids on the genomic scale
Dr. Uroš Petrovič
3. Computational phenomics
Dr. Uroš Petrovič

RESEARCH PROGRAM

1. Toxins and biomembranes
Prof. Igor Križaj

NEW CONTRACT

1. Protein N-terminal sequence analysis
Lek farmacevtska družba d.d.
Prof. Igor Križaj

VISITORS FROM ABROAD

1. Dr. Beata Halassy Špoljar, Marija Brgles, Imunološki zavod, Odjel za istraživanje i razvoj, Zagreb, Croatia, 7. 2. 2007.
2. Dr. Lidija Habjanec, Imunološki zavod, Odjel za istraživanje i razvoj, Zagreb, Croatia, 31. 8. 2007.

3. Dr. Beata Halassy Špoljar, Imunološki zavod, Odjel za istraživanje i razvoj, Zagreb, Croatia, 19. 10. 2007.
4. Dr. Grazyna Faure, Institut Pasteur, Paris, France, 12.-18. 11. 2007.
5. Prof. Dr. Sepp Kohlwein, Institute of Molecular Biosciences, University of Graz, Austria, 20.-21. 12. 2007.

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The application of modern biotechnology in human and veterinary medicine, plant protection, food production and improving and monitoring a healthy environment

Biologically active proteins from model mushrooms, in particular cysteine protease inhibitors mycocypins, represented an important part of the research in 2007. We analyzed the inhibitor macrocypin from basidiomycete *Macrolepiota procera* (parasol mushroom) at the genetic level and the gene and promoter sequences were determined. The macrocypin gene structure is the same as that of the cysteine protease inhibitor clitocypin from basidiomycete *Clitocybe nebularis* (clouded agaric, clouded funnel). The genetic heterogeneity, on the other hand, is greater for macrocypin (Mcp) than for clitocypin (Clt), as we identified three macrocypin isoforms (McpA12, McpA3, McpB) based on the presence of a cysteine residue. The sequence identity deduced from the DNA sequence among the isoforms was 80–86%, while the identity of the protein sequence was 95%. Macrocypin has similar biochemical properties to clitocypin, although they share only 21% amino acid sequence identity. Several amino acids conserved in both inhibitors are probably important for their inhibitory activity.

We analysed mycocypin expression regulation during basidiocarp development using the model basidiomycete *Coprinus cinereus* and green fluorescent protein. Two different lengths of clitocypin promoter sequence showed a similar expression regulation as the constitutively expressed promoter of a glycolysis enzyme from *Agaricus bisporus*. On the other hand, different lengths of macrocypin promoters' sequences showed that different macrocypin isoforms might have different physiological roles. The specifically localized expression of the macrocypin A12 isoform promoter in protective tissues during basidiocarp development and in scales on top of the cap and a ring at the bottom of the stipe in the mature basidiocarp suggests a defensive role for macrocypin A12.

The research of CnSPI (the inhibitor of serine proteases from *Clitocybe nebularis*) was extended to studying its inhibitory spectra using the following proteolytic enzymes: trypsin, chymotrypsin, kallikrein, elastase, thrombin, subtilisin BPN' and protease K. We also succeeded in analysing the complete gene for CnSPI, including the promoter and terminator regions. A simple system for the expression of homogenous recombinant CnSPI with the help of an expression system in bacteria *E. coli* was established. Checking of its identity with the native inhibitor is in progress.

In the field of lectins the rough characterization of lactosil lectin 19 kDa, also from *C. nebularis* was accomplished. By studying the inhibition of agglutination of erythrocytes after the addition of di- and polysaccharides from different sources we determined its specificity, which together with its gene sequence shows for the ricin type of lectin, but with a relatively low similarity. The isolated lectins from mushrooms were used in the cell systems to test their impact on the proliferation of immune cells.

Extracts from mushrooms that contained protease inhibitors and lectins were used in the screening tests for studying the influence on the inhibition of growth of the selected plant bacteria. Four sorts of mushrooms stood out; they effectively retarded the growth of bacteria *in vitro*, one of them also *in vivo* in a tomato plant. The preliminary results show that the active substance that causes the inhibition is protein in nature.

The studies of the adaptation of digestive enzymes of the Colorado potato beetle were continued. The beetles were feeding on different transgenic potato plants with a damaged plant-protection mechanism (metabolism of jasmonic and salicylic acid). From 17-25 larvae, grown on each plant construct, the digestive organs were isolated and tested for their activity on substrates of Z-Phe-Arg-pNA (in the presence and absence of chicken cystatin) and p-Glu-Phe-Leu-pNA. In all cases the activity in larvae fed on the transgenic plants was lower than on the wild type. The induction of the inhibitors of cysteine proteases in the leaves of the transgenic plants after the attack of the Colorado potato beetle was also tested. The lowest percentage of the inhibition was determined in the plants with the damaged receptor for methyljasmonate.

In higher plants the molecular mechanisms of adaptation of the plant to drought were studied. For this purpose the 2-D electrophoresis of the cell extracts from the leaves of the model plant *Ramonda serbica*, which is tolerant for drying to the humidity in the ear, was optimized. The protein profiles of the desiccated and the control plants



Head:
Prof. Janko Kos



Figure 1: The optimisation of brazzein expression was performed simultaneously in four fermentors Minifors (ATR Biotech).

were obtained. In next step the proteins specific to the response of a plant to the drought will be identified using mass spectrometry. We demonstrated that a different degree of water deficit affects the activity of different serine proteases in the leaves of *Phaseolus vulgaris*.

The research on the endogenous inhibitors of cysteine proteases involved in the immune response of humans was continued. Previous studies showed cystatin F as an interesting inhibitor, present mainly in immune cells. We were especially interested in the mechanism of transformation of the inactive dimer form of cystatin F into its active monomer form. It was determined that the dimeric inhibitor is not the endogenous substrate for the reduction with the GILT enzyme, which is the only known lysosomal reductase. The N-terminal part of the monomeric inhibitor can be cleaved in cells with unknown lysosomal protease, which is specifically present in immune cells, but it is not cysteine cathepsin, legumain, cathepsin D or leukocytic elastase. Using the recombinant cystatin F (the wild type and the mutant N65A) the kinetics and stoichiometry of the binding of cystatin F and legumain and cysteine proteases of the C13 family were investigated.



Figure 2: *Coprinus cinereus*. Mushrooms represent a new source of natural compounds, including lectins, peptidases and their inhibitors. Many of them are present exclusively in mushrooms.

The expression of the sweet protein brazzein in *Lactococcus lactis* was optimized on the fermentor scale level. In cooperation with the Biotechnical Faculty of the University of Ljubljana a series of 34 experiments of brazzein expression under controlled conditions were completed. We studied the influence of pH, the quantity of the inducing agent, the OD at induction, the composition of the culture medium and the growth in the aerobic conditions with the addition of hemin on the level of the expression. We determined the optimal conditions, which resulted in a 17-times increased amount of the expressed brazzein. The great influence of pH and carbohydrates as the components of the medium was observed. A new method based on ELISA was also developed; this allows an accurate quantification of brazzein with histidine tag in the bacterial lysate and an easier comparison of its quantity between the samples.

The expression of brazzein was much better in the new system of *Lactococcus lactis* (plasmid pNZ8148 and strain NZ9000, which is compatible with plasmid) with an 800-times better yield in comparison with the system plasmid pMSP3545 – strain IL1403 and comparable with the expression in bacteria *Escherichia coli*. Despite the higher expression the secretion to the medium was not better, which indicates the problem with the crossing of the cell wall. Brazzein expressed in the new system was not sweet, which probably indicates the incorrect folding of the protein.

In 2007 the research results of the members of the Department of Biotechnology were published in 18 articles and reviews with an impact factor and presented at scientific conferences as invited lectures and posters. The members of the department were also active in the pedagogical field, as they contributed as lecturers and supervisors to students at the University at Ljubljana, University of Maribor and the JSI International Postgraduate School. In the past year members of the department received the national Zois award for research work and the Krka award for student research results.

Some outstanding publications in the past three years

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Organization of conferences, congresses and meetings

1. Jože Brzin, Jerica Sabotič, members of organizing committee 4th International Medicinal Mushroom Conference (IMMC4) 23.-27. 9. 2007
2. Janko Kos, Borut Štrukelj; members of scientific board of 7th Meeting of Slovenian Biochemical Society

Awards and appointments

1. prof. Borut Štrukelj; Zois award for research work
2. dr. Tomaž Langerholc; Krka award for doctoral thesis: Preparation and characterization of cystatin F and its role in antigen presentation (prof. dr. Janko Kos)

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THESES

Ph. D. Theses

- Tomaž Bratkovič: Development of peptide inhibitors of cysteine proteases and Mur ligases through phage display technology (Borut Štrukelj, co-mentor)
- Matjaž Hren: Interactions between phytoplasma and grapevine (*Vitis vinifera* L.) at the level of gene expression (Kristina Gruden)
- Boštjan Japelj: Structural and biophysical properties of antimicrobial peptides (Borut Štrukelj, co-mentor)
- Tomaž Langerholc: Preparation and characterisation of cystatin F and its role in antigen presentation (Janko Kos)
- Maja Kenig: Development of affinity chromatography methods for isolation of recombinant proteins from *Escherichia coli* (Borut Štrukelj, co-mentor)
- Jernej Kristl: Differential expression of genes in human keratinocytes after treatment with calcipotriol (Borut Štrukelj)
- Jerica Sabotič: Characterization of mycocypins from selected basidiomycete species using genetic and protein engineering (Borut Štrukelj, Jože Brzin)

B. Sc. Theses

- Ana Balorda: Phage display library amplification and its use in search of peptide ligands that bind to an essential bacterial enzyme (Borut Štrukelj)
- Katja Barle: Study of proteome of potato leaves (*Solanum tuberosum* L.) as tool to assess safety of transgenic plants (Kristina Gruden)
- Roswita Golčer: Isolation and characterization of cysteine proteinases from (*Chelidonium majus* L.) (Jože Brzin)
- Jana Herman: Determination of polymeric impurities in traces in recombinant substances in bacteria *Escherichia coli* (Borut Štrukelj)
- Lara Kandič: Insecticidal activity of proteins from selected species of fungi and plants on fruit fly model insect (Borut Štrukelj)
- Špela Magister: Expression and isolation of cathepsin X in THP-1 cell line, stimulated with the antigens of bacteria *Helicobacter pylori* (Janko Kos)
- Dušan Rusić: Safety aspects of production and usage of biopharmaceuticals: (Borut Štrukelj)
- Maja Souvan: Similar biological medicinal products: development and registration in European Union (Borut Štrukelj)
- Sabina Vatovec: Self-incompatibility and microtubulus cytoskeleton in peled of plant *Papaver rhoeas* (Kristina Gruden)
- Mojca Vrhovnik: Characterisation of alanine aminopeptidase and leucine aminopeptidase that are affected by drought from bean leaves (Marjetka Kidrič)
- Urška Zalokar: Evaluation of monoclonal antibody raised against human cytokeratines (Janko Kos)

INTERNATIONAL PROJECT

- Functional Analysis of Fungal Cysteine Protease Inhibitor
PSP, BI-GB/06-002
Dr. Gary Foster, The University of Bristol, Bristol, Great Britain
Dr. Jože Brzin

R & D GRANTS AND CONTRACTS

- Molecular mechanisms of the resistance to abiotic stress in bean
Dr. Marjetka Kidrič
- Lectins as modulators of antitumour immune response
Prof. Janko Kos

- Evaluation of genotypes of bean (*Phaseolus vulgaris* L.) by using candidate genes involved in drought resistance
Prof. Janko Kos
- Food supplements for optimal nutrition in extreme conditions
Prof. Janko Kos

RESEARCH PROGRAM

- Pharmaceutical biology: Man and environment
Prof. Janko Kos

VISITORS FROM ABROAD

- Dr. Mary Heneghan, University of Bristol, School of Biological Sciences, UK, 26. 1.-31. 1. 2007

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DEPARTMENT OF ENVIRONMENTAL SCIENCES 0-2

The activities of the Department of Environmental Sciences are interplayed between research, development and education in the fields of environmental analytical chemistry; radiochemistry and radioecology; the biological and geochemical cycles of elements; food and human, animal and plant health; waste management; mathematical and GIS modelling of environmental processes; as well as risk and environmental impact assessments.

In the field of environmental analytical chemistry special attention was devoted to organotin (OTC) compounds, which are very toxic and can be found in different aquatic and terrestrial environments. Up to now researchers have studied mostly the presence of OTC in biological samples (mussels), seawater, and sea sediments. Very little information is available on the presence of OTC in soil samples. An analytical procedure for determining butyl- and phenyl-tin compounds in soils with the use of solid-phase microextraction (HS-SPME) and gas chromatography with pulse-flame photometric detection was developed. Swamp soils, rich in organic matter and with a high ion-exchange capacity, and clay soils, poor in organic matter and with a high ion-exchange capacity, were analyzed. The recovery for both the investigated matrices were mostly 80% or better, with a reproducibility of 10%, while the detection limit and the quantification for the investigated OTC were in the range of ng Sn g⁻¹. On the basis of the developed analytical method it is possible to follow the input and transformations of the OTCs in terrestrial environments.

Some new extraction procedures for biomarkers (fatty acids, lipids) and their stable C and H isotope analyses using GC-C-IRMS were introduced. The first compound-specific stable isotope analyses were performed on biomarkers in some environmental samples and in fatty acids in oils. A method for stable isotope analysis of the hydrogen in saliva was optimized; this method is used for an estimation of the bulk body water. A procedure for the isolation of cellulose from tree rings for C stable isotope analysis was introduced, too. The C and O isotope ratios in wood biomass are an important indicator of climate change. In cooperation with the Joanneum Research Institute (Austria), stable isotope analyses of the C and H in essential oils were applied to estimate their origin.

The relevant equations in accordance with metrological principles were derived for uncertainty propagation factors in the k_0 -method of neutron-activation analysis. An appropriate computer program was developed to calculate the measurement uncertainty. The uncertainty propagation factors were studied for various experimental conditions and experimentally verified. The influence of the particular nuclear parameters on the measurement results was compared for different research reactors.

In 2007 new improvements in the software for the k_0 instrumental neutron-activation analysis method (k_0 -INAA) for a determination of the main and trace elements in environmental samples were made. We collaborated in the IAEA validation programme and in comparison tests organized by certification agencies, i.e., IAEA (Austria), NIST (USA), IRMM (Belgium), BAM (Germany), and APAT (Italy). The k_0 -INAA method was used for the characterization of some products from the pharmaceutical and petroleum industries.

The radiochemical neutron-activation (RNAA) method for a determination of ¹²⁹I in environmental samples was developed in 2006, and was used in 2007 for a determination of the ¹²⁹I in brown algae, which are endemic species and grow on the rocky coast of the Adriatic sea. Our results confirmed that the ¹²⁹I is present in algae, which is in agreement with the literature data. The main sources of ¹²⁹I in algae are the dry (aerosols) and wet (precipitation)



Head:
Prof. Milena Horvat

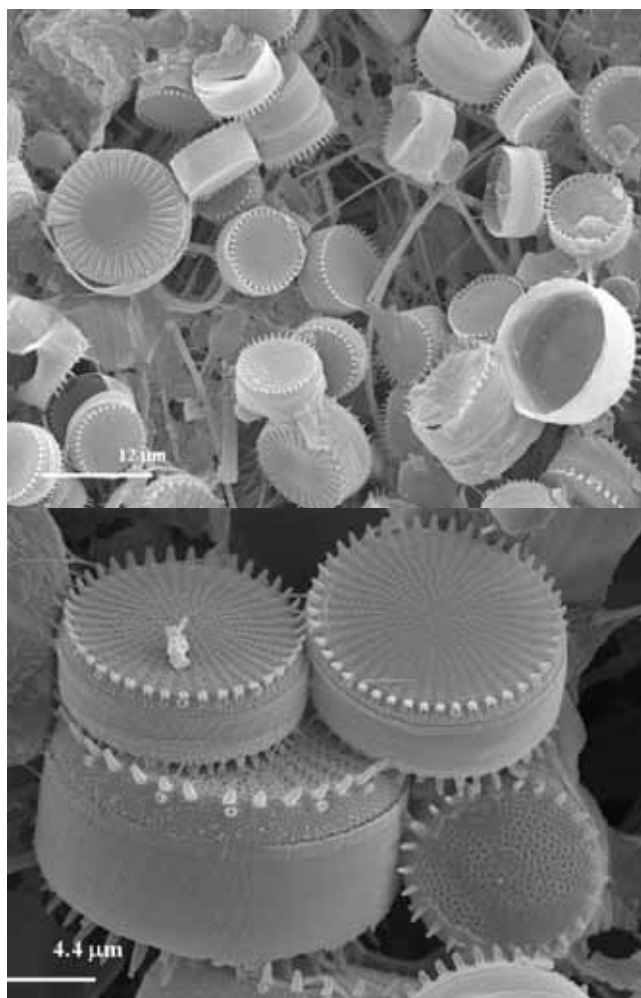


Figure 1: SEM/EDS image of particulate material collected at Košutarica on the River Sava, where diatom algae (*Stephanodiscus hantzschii*) is present.

deposition of ^{129}I , which originates from the nuclear fission processes in nuclear reactors and is emitted into the environment mainly from plants that process used nuclear fuel.

In the radon centre the main attention was focused on short-lived radon-decay products (RnDP): Po-218, Pb-214, Bi-214, and Po-214, which originate in the radioactive decay of radon and are present in the atmosphere as nanoparticles with a size up to 10 nm and as radioactive aerosols of size 200 to 600 nm. Free and bounded nanoparticles are settled on the walls of respiratory organs. Because of its nanoproperties, free RnDP acts differently to bounded RnDP; its impact on the tissue, which is measured with the so-called dose-conversion factor (DCF, that converse activity of RnDP to dose), is mostly much higher than for bounded RnDP. Research on radon nano-decay products in different environments was started. One of the selected environments was schools with elevated Rn levels, where concentrations of RnDP in the air were measured. The investigations covered how temperature, air humidity, working regime and ventilation influence their proportion in the air. Research on radon in ambient and working environments was continued. Measurements of Rn in soil gases at 70 locations around Slovenia were performed in order to identify the radon-threatened areas. For these areas the influence of the residence and working habits, and the meteorological parameters on RnDP were studied. These results will make an important contribution to the improvement of radon dosimetry.

Among the important department achievements is the research in the field of drug remains in the environment. In the new research field of the identification of drugs' decay products within the cleaning of waste-water procedure, the production of drinking water and in the environment, different chromatographic and mass spectrometric

methods were used for the identification of numerous decayed drug products that are formed by biotic and abiotic transformations. At the same time, the increased toxicity of some stable metabolite products in comparison to the original drugs was shown.

Research on the selenium intake into plants was continued. Plants are capable of taking in larger amounts of selenium and are interesting as a food source for humans and animals. The bioavailability of selenium depends on the species in which it is present. In cooperation with the Department of Agronomy of the Biotechnical Faculty in Ljubljana and the National Institute for Biology, plants from seeds, which were irrigated in solutions with different concentrations and species of selenium or cultivated by selenate, were planted. In all cases the dominant compound in the plants was selenoamino acid selenomethionine.

A radiological survey of seawater, sediments, fish and mussels in the Slovenian sea was performed. In the collected samples, the content of Cs-137 in the seawater, gamma emitters, using high-resolution gamma spectrometry, in sediments, fishes and mussels, as well as Po-210 in fishes and mussels, were determined. High-resolution gamma-spectrometry measurements revealed that the content of gamma emitters in samples was low. The authenticity and geographical origin of foodstuffs were assessed using stable isotope ratios of light elements (C, O, N) in wine, olive oils, honey, fruit juices, milk, etc. The department also contributes to monitoring data of the EU Wine Databank.

Studies of the biogeochemical cycling of carbon in forest ecosystems using stable C isotopes in relation to climate change are conducted in cooperation with the Forestry Institute of Slovenia. Two main topics are tackled: storage and release of CO_2 from forest soils, and tracing climate change based on the stable isotope composition of C in tree-ring cellulose. Our results show that Slovenian forests not only store, but also release CO_2 . The origin of the CO_2 in forest soil was traced using natural ^{13}C . It was found that the main soil CO_2 sources are soil respiration and the weathering of carbonate bedrock, which can contribute up to 50% to the total CO_2 mass balance.

In cooperation with archaeologists we have tried to elucidate the dispute about whether the Ljubljana marsh was covered by a lake during the Early and Middle Holocene periods. The results of a complex multidisciplinary investigation point toward the vivid dynamics of this environment, which was most probably a flood plain covered by oxbow lakes, small lakes and marshes. Variations in the C and N isotope compositions of the sediments near Babna Gorica indicate varying sources of organic matter – terrestrial and aquatic – and documents the dynamic transitions between dry and wet (flooded) conditions in the period before 5200 B.P.

In the framework of the SARIB (Sava River Basin) project an extensive study of hydro-chemical parameters in the river basin was performed. The transformation processes and the transport of C and N and the degree of pollution were evaluated for the entire river basin. The stable isotope and geochemical parameters were evaluated as palaeoenvironmental and palaeotemperature proxies in laminated river carbonates. It was found that their accuracy critically depends upon the hydrological and precipitation regime in the area of interest rather than the temperature conditions. Vegetation cover and anthropogenic activities (industry, land use) also affect the reliability of the predicted precipitation temperatures of carbonates.

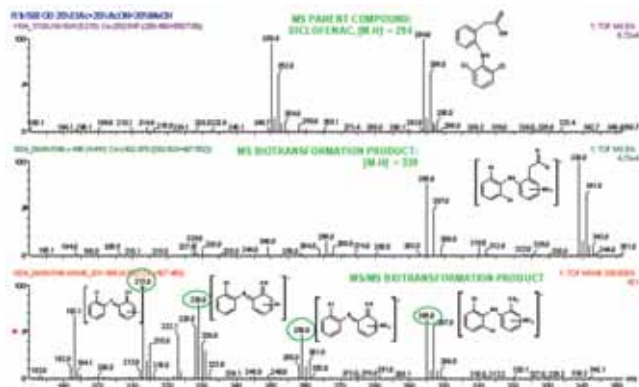


Figure 2: Identification of the decay drug products that are formed by biotic and abiotic transformations in waste and drinking waters.

Regular monitoring of the stable isotope composition of dissolved carbon and oxygen in soil water and in precipitation is performed at the experimental plot at Brdo pri Kranju, which is a part of the national forest-monitoring programme, and also included into the EU project CarbonPro. The stable isotope of water and the ^3H activity are regularly monitored and reported to the ISOHIS/GNIP database.

The migration of nitrate in the plant–soil–groundwater system was traced using labelled N fertilizer (K^{15}NO_3). Based on the N isotope and the mass balance the most appropriate agricultural practices and fertigation regimes were recommended for the production of lettuce and white cabbage. This study is a part of the research supporting the implementation of the Water Framework Directive in Slovenia.

Stable isotopes of N at natural levels were applied for tracing the nitrogen flow in ecosystems affected by aquaculture and in water-treatment plants.

A detailed investigation of biogeochemical cycling of members of the uranium-radium decay series was initiated under the specific conditions within the area of the former uranium mine at Žirovski vrh. Special emphasis will be on partitioning, transfer, mobility and the biological uptake of the radionuclides among different environmental compartments such as water, soil (tailing) and plants.

Researchers from the department participated in two regional projects of the International Atomic Energy Agency (IAEA) concerned with collecting internationally comparable data on air and marine pollution within the Mediterranean area as well as in radiological monitoring surveys of the Krško nuclear power plant and the Žirovski vrh uranium mine.

On the influenced area of the former mercury mine in Idrija, work was focused mainly on the production and development of erosion models for the simulation of mercury transport in the Idrija River catchment area. On the Idrija River research was focused on periphyton in natural and artificial (glass) substrates. Periphyton sampling and in-situ measurements of crucial abiotic factors (physical and chemical) were performed during all seasons of the year. The composition of the periphyton silica algae (*Diatomeae*) on the natural and artificial substrates was analyzed in order to establish the differences in species diversity in different river burdens. With use of the radioactive isotope ^{197}Hg the processes of mercury methylation ($\text{Hg}^{2+} \rightarrow \text{MeHg}$) and reduction ($\text{Hg}^{2+} \rightarrow \text{Hg}^0$) were followed.

In cooperation with the University Medical Centre, Ljubljana, research on mercury's influence on the health of Idrija habitants was continued, especially on women of child-bearing age and pregnant women.

Among the work for industry, the most important were studies on mercury, its species and some other toxic and non-toxic and cycling in combustion systems in clinker production in the cement plant Saloni Anovo and in electricity production at the Šoštanj Thermal Power Plant.

The department collaborated in the working group CEN/TC 264/WG 25, which prepares European standards for measuring the total gaseous mercury (TGM) in the atmosphere and the mercury deposition by precipitation. Before preparing the standards, different European institutions tested different types of TGM measuring equipment and sampling devices and procedures for Hg deposition that are currently used in Europe. The testing of samples and sampling procedures in Slovenia was performed in the vicinity of the Šoštanj Thermal Power Plant.

In the field of waste management, an overview of the waste-management practices in the Ljubljana Municipality was made in collaboration with the Energy Efficiency Centre. A study of the emission register of persistent organic pollutants and the action plan for unintended POPs emission reduction was conducted. Emissions of 7 POPs into the atmosphere were calculated for Slovenia for the period 1990 to 2004. An operative programme of measures for the decreasing POPs emissions was proposed.

The conditioning of liquid uranium containing technological radioactive waste emerging from the past research activities at the Jožef Stefan Institute was carried out for the Agency for Radwaste management. The overall process resulted in a substantial volume reduction of the waste that was initially present.

We continued our research related to PCB pollution in the Krupa river karstic region in Bela krajina. The relevancy of the pathways and exposure modes depends on the characteristics of the PCB pollution, particularly the karstic environment, and human habits. In the case of the Krupa River the underground water pathway is the most relevant. It is crucial to recognize and understand how PCBs have been transported, i.e., distributed in the environment.

Projects in 2007 were primarily associated with a strategic (spatial) environmental evaluation. The project "A case-study integration of risk assessment into spatial development planning of the Municipality of Koper" dealt with making the threat analysis a part of the overall spatial planning process. The project "Analysis of changes of

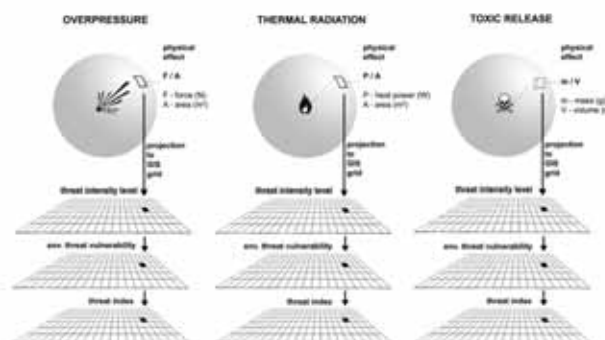


Figure 3: A schematic presentation of the transfer of risk assessment results into a threat analysis and GIS.



Figure 4: Schematic presentation of the integration of the threat analysis into the spatial planning process.

radiological and thermal pollution of the Sava River due to operation of the NPP Krško after the construction of the HPP Brežice” was investigating changes in the safe operation of the NPP Krško and its environmental and radiological effects after constructing HPP Brežice. The primary concern was the changed hydrological regime of the Sava River after an accumulation lake was formed behind a dam at the HPP. The results show that changes in the radiological and other impacts will be negligible since NPP releases radioactivity in amounts that contribute only up to 1 nSv to the annual dose to the most exposed group of the population around the NPP. A targeted research project on the sustainability of the Port of Koper is aimed at clarifying the role and the contribution of the Port of Koper to the development of the coastal region. Our results show that the port contributes significantly to an improvement in environmental qualities at the local level; however, more should be done at the regional level and in terms of public-health investments.

A targeted research project on TIA (Territorial Impact Assessment) explores the impacts of the energy policy of Slovenia on the goals of spatial cohesion. Preliminary results provide an insight into the whole heterogeneity of the issue and the difficulty in specifying the impacts on individual territorial cohesion components: spatial efficiency, identity, and quality.

Outstanding achievements:

1. In the new research field of identifying the decay products of drugs within the cleaning of waste-water procedure, the production of drinking water and in the environment, different chromatographic and mass spectrometric methods (UPLC-Q-ToF, GC-MSD, GC-IT-MS⁹) were used for the identification of numerous decayed drug products that are formed by biotic and abiotic transformations. At the same time, the increased toxicity of some stable metabolite products in comparison to the original drugs was shown.
2. The unattached fraction of radon short-lived decay products (f_{un}), present in the air as nanosized clusters, is the crucial parameter in dose calculations. In order to improve radon dosimetry, the influence of the working regime and the living habits on the unattached fraction has been studied in kindergartens and schools.

Some outstanding publications in 2007

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- Michael Beeston: Chemical availability of arsenic - measurement and risk assessment (Z. Šlejkovec)
- Andrej Osterc: Distribution of 129 I in the environment (V. Stibilj)
- Tadeja Milivojevič Nemanič: Development of analytical methods for determination of organotin compounds in marine environment (R. Milačič)

B. Sc. Theses

- Alja Dolinar: Determining of selenium levels in arterial, venous and total umbilical cord blood and their fractions (V. Stibilj)
- Janez Klavž: Levels of Polychlorinated Biphenyls in Commercial Fish Species in Slovenia (E. Heath)
- Irena Rupnik: Determination of total and methyl mercury in hair and cord blood (M. Horvat)
- Tina Šturm: Chemical characterization of waste materials from steel industry and potential use of these materials in civil engineering and road construction (J. Ščančar)
- Marko Zupancič: The influence of geology and climate on radon levels in outdoor air (J. Vaupotič)

INTERNATIONAL PROJECTS

- A Future for Radioecology in Europe
FUTURAE, 6. FP, 036453
EC, Dr. Jean-Christophe Gariel, Institut de Radioprotection et de Sureté Nucléaire, Clamart, France
Prof. Borut Smodiš, Asst. Prof. Branko Kontič
- Public Health Impact of Long-term, Low-level Mixed Element Exposure in Susceptible Population Strata
PHIME, 6. FP, 016253
EC, Prof. Staffan Skerfving, Lund University Hospital, Dept. of Occupational and Environmental Health, Lund, Sweden
Prof. Milena Horvat
- Network of Reference Laboratories and Related Organizations for Monitoring and Bio Monitoring of Emerging Environmental Pollutants
NORMAN, 6. FP, 018486
EC, Dr. Valeria Dulio, INERIS - Direction Scientifique, Verneuil-en-Halatte, France
Dr. Ester Heath
- Sharing Experience on Risk Management (Health, Safety, Environment) to prepare Future Industrial Systems
SHAPE-RISK, 6. FP
NMP2-CT-2003-505555
EC, Institut National de l'environnement industriel et des risques, Verneuil en Halatte, France
Asst. Prof. Branko Kontič, Asst. Prof. Marko Gerbec
- Worldwide Remediation of Mercury Hazards through Biotechnology
BIOMERCURY, 6. FP
NMP2-CT-2004-505561
EC, Gesellschaft für Biotechnologische Forschung MBH, Braunschweig, Germany
Prof. Milena Horvat, Dr. Andrej Stergaršek
- Sava River Basin: Sustainable Use, Management and Protection of Resources
SARIB, 6. FP
INCO-CT-2004-509160, EC
Asst. Prof. Radmila Milačič
- Lead Free Solder Materials
COST 531, EC
Dr. Arkadij Popovič
- Xenobiotics in the Urban Water Cycle
COST 636, EC
Dr. Ester Heath
- Hazardous Waste Management Training Programme
HAZTRAIN, Leonardo da Vinci
IRL-04-B/P-PP-153225

- EC, Clean Technology Centre, Cork Institute of Technology, Cork, Ireland
Prof. Borut Smodiš
10. Isotope Investigation of the River Sava in Slovenia: Long-term Isotopic Monitoring of Surface Water and Precipitation at Selected Sites
14343/R0
IAEA, Vienna, Austria
Asst. Prof. Nives Ogrinc
 11. Measurements and Calculations of the Neutron Spectrum in Different Irradiation Channels of the TRIGA Mark II Reactor, Slovenia
13279/R1
IAEA, Vienna, Austria
Dr. Radojko Jačimović
 12. Nutritional Status and Exposure to Mercury and its Compounds in Pregnant Women and Women of Childbearing Age in Former Mercury Mining Site using Nuclear and other Techniques; Exposure to Toxic and Potentially Toxic Elements in Women of Childbearing Age in Developing Countries
13250/R1, R2
IAEA, Vienna, Austria
Prof. Milena Horvat, Dr. Jože Kotnik
 13. Training of Mr Dennis Kpakpo Adotei
IAEA Fellow, GHA/07017
IAEA, Vienna, Austria
Prof. Vekoslava Stibilj
 14. Training of Ms Olja Jotanović
IAEA Fellow, BOH/07023
IAEA, Vienna, Austria
Prof. Borut Smodiš
 15. Training of Mr Nabil Benfaid
IAEA Fellow, LIB/05015
IAEA, Vienna, Austria
Prof. Vekoslava Stibilj
 16. Sources and Sinks of Mercury in Freshwater Ecosystems
BI-AR/06-08/01
Prof. Ribeiro Guevara Sergio, Centro Atómico Bariloche, Comisión Nacional de Energía Atómica, Bariloche, Argentine
Prof. Milena Horvat
 17. Isotope Ratio Analysis of Essential Oils for Authenticity Assessment
Forschung Austria Fellowship
Susanne Wagner, M. Sc., Joanneum Research Forschungsgesellschaft mbH, Institut für Nachhaltige Technik und Systeme, Graz, Austria
Dr. Polona Vreča
 18. Characterisation Study for Total Br in Polymers (EC590 and EC591)
P048609
Katharina Teipel, Connie Biesmans, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Dr. Radojko Jačimović
 19. Stability Test BCR 403 (Sea Water), BCR-463 (Hg Species in Tuna Fish), ERM-CE464 (Hg Species in Tuna Fish), BCR-505 (Estuarine Water), BCR-579 (Mercury in Seawater), ERM-CC580 (Estuarine Sediment), BCR-679 (with Cabbage)
IRMM.B047359
Hendrik Emons, Dr. Guy Auclair, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements, (IRMM), Geel, Belgium
Prof. Milena Horvat
 20. Characterisation of Measurements for Trace Elements in Plastics
IRMM.B045069
Thomas Linsinger, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Dr. Radojko Jačimović
 21. Radioecological Investigations in the Territory of Bosnia and Herzegovina
BI-BIH/05-06-009
Dragana Stojisavljević, M. Sc., Bojan Štrbac, B. Sc., Public Health Institute of Republic of Srpska, Banja Luka, Bosnia and Herzegovina
Prof. Borut Smodiš
 22. Određivanje uranovih radioizotopa u uzorcima okoline
BI-BIH/06-08/007
Dr. Stjepan Marić, Zavod za javno zdravstvo FBiH, Sarajevo, Bosnia and Herzegovina
Dr. Ljudmila Benedik
 23. Radioekološka istraživanja na području Bosne i Hercegovine
BI-BIH/06-08/009
Dr. Marko Lalić, Institut za zaštitu zdravlja Republike Srpske, Banja Luka, Bosnia and Herzegovina
Prof. Borut Smodiš
 24. Spectroscopic and Chemometric Characterization of Slovene and Cypriot Fruit Juices
Dr. Rebecca Kokkinofa-Diogenous, Ministry of Health - State General Laboratory, Acropolis, Nikozija, Cyprus;
Dr. Iztok Jože Košir, Slovenian Institute for Hop Research and Brewing, Žalec, Slovenia
Asst. Prof. Nives Ogrinc
 25. Udvikling af innovative teknologier for kvantificering og fjernelse af miljøfremmede stoffer fra spildevand
Development of Innovative Technologies for Determination and Treatment of Xenobiotic Organic Compounds in Eastewater
BI-DK/07-09-003
Prof. Anna Ledin, Institute of Environment & Resources, Technical University of Denmark, Bygningstorvet, Lyngby, Denmark
Dr. Ester Heath
 26. Organotin Compounds and Selected Metals in Freshwater and Terrestrial Environment: Mobility and Transfer between Solid and Aqueous Phases
BI-FR07-PROTEUS-006, PROTEUS
Prof. Gaetane Lespes, Laboratoire de Chimie Analytique, Bio-Inorganique et Environnement, UMR CNRS 5034, Université de Pau et des Pays de l'Adour, Pau Cedex, France
Dr. Janez Ščančar
 27. Biogeochemical Cycling of Carbon and Assessment of Shifts in Sediments in Lake Pamvotis (Greece) and Bohinj (Slovenia)
BI-GR/04-06-006
Dr. Constantine Stalikas, University of Ioannina, Department of Chemistry, Laboratory for Analytical Chemistry, Ioannina, Greece
Dr. Polona Vreča
 28. Study of Defects in Si and Ge Irradiated by Fast Neutrons
BI-HR/07-08-030
Dr. Branko Pivac, Rudjer Bošković Institute, Zagreb, Croatia
Dr. Radojko Jačimović
 29. Formation of Recent Carbonate Sediments in Karstic Aquatic Environments
BI-HR/06-07-001
Dr. Ivan Sondi, Rudjer Bošković Institute, Zagreb, Croatia
Asst. Prof. Sonja Lojen
 30. Geochemical Investigation of Tufa Barriers in the Krka National Park
Dr. Neven Cukrov, Rudjer Bošković Institute, Zagreb, Croatia
Asst. Prof. Sonja Lojen
 31. Characterization of Food Products in Apulia and Slovenia by Spectroscopic and Chemometric Methods: Similarities and Differences
BI-IT/05-08-013
Prof. Antonio Sacco, Università di Bari, Dipartimento di Chimica, Bari, Italy
Asst. Prof. Nives Ogrinc
 32. Mercury Emission, its Influence and its Correlation to Radon in Mount Etna Area
BI-IT/05-08-026
Dr. Salvatore Giammanco, Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Palermo, Palermo, Italy
Dr. Jože Kotnik
 33. Monitoring of Chemical and Physical Parameters at the Seismic Active Zone at the Slovenian Italian Border at the Etna Volcanic Area
BI-IT/05-08-027
Dr. Anna Riggio, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Sgonico (Trieste), Italy
Asst. Prof. Janja Vaupotič
 34. The Estimation of the Impact of Mercury Released in Environmental by a Human Activity
The Behavior of Mercury Released from the Mining Area
JSPS - Grant no. 15404003
Prof. Takashi Tomiyasu, Kagoshima University, Faculty of Science, Department of Earth and Environmental Sciences, Japan
Prof. Milena Horvat
 35. Modelling of Mercury and its Compounds in Polluted Freshwater Systems: Comparison between Reservoirs in the Guizhou Province and the Idrija River System
BI-CN/07-09-009
Prof. Xinbin Feng, State Key of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, China
Dr. Jože Kotnik
 36. Integration of Hg Removal (RHg) in the Process of Flue Gas Desulphurization (FGD) in Thermal Power Plants
BI-CN/05-07/025
Yan Yin Jiang, Shanghai Research Institute of Environmental Industry, Shanghai Academy of Environmental Sciences, Shanghai, China
Prof. Milena Horvat
 37. Elemental Composition of Minerals from The Republic of Macedonia
BI-MK/07-08-023
Dr. Trajče Stafilov, Faculty of Natural Sciences and Mathematics, Skopje, The Republic of Macedonia
Dr. Radojko Jačimović
 38. WG 25 Validation Measurements
CEN/TC 264/WG 25/338, M/360, SA/CEN/ENV/000/2005-37
Ir. Jan A. Wesseldijk, Nederlands Normalisatie-instituut, Delft, The Netherlands
Prof. Milena Horvat, Dr. Jože Kotnik
 39. Radon Potential on Different Geologic Basis
BI-PL/05-07-001
Dr. Zdzisław Krzyżstof, The Henryk Niewodniczanski, Institute of Nuclear Physics of the Polish Academy of Sciences, Department of Environmental and Radiation Transport Physics, Natural Radioactivity Laboratory, Krakow, Poland
Asst. Prof. Janja Vaupotič
 40. Accumulation of Mercury and Methylmercury in Natural Forest Sites in Switzerland
U3-12/06
Dr. Beat Frey, Swiss Federal Research Institute WSL, Soil Sciences, Birmensdorf, Switzerland
Prof. Milena Horvat
 41. Organic Geochemistry and Microbial Ecology of Stratified Eutrophic Alpine Lakes
Prof. Stuart Wakeham, Skidaway Institute of Oceanography, Savannah, GA, USA
Prof. Jadran Faganeli, Nacionalni inštitut za biologijo, Morska biološka postaja Piran, Slovenia
Asst. Prof. Nives Ogrinc

R & D GRANTS AND CONTRACTS

- Stress and response to the stress in terrestrial isopode *Porcellio scaber* and in water leek *Lemna minor*: mechanistic approach
Prof. Milena Horvat
- Biogeochemical cycling of carbon and nitrogen in eutrophic lakes
Dr. Polona Vreča
- Biogeochemical cycles and pollution with organotin compounds: development and validation of analytical procedures
Dr. Janez Ščančar
- Pathways of carbon, nutrients and pollutants through food webs in Slovenian mountain lakes
Prof. Milena Horvat
- The impact of microbial processes on Hg biomagnification in food webs of the Gulf of Trieste (N Adriatic Sea)
Prof. Milena Horvat
- Development and validation of toxicity test for nanoparticles using terrestrial isopods
Dr. Ingrid Falnoga
- CO₂ fixation in river carbonates: mass balance, hydrological, geochemical and biochemical controls
Asst. Prof. Sonja Lojen
- Identification of structures, soils and defects
Asst. Prof. Janja Vaupotič
- As₂O₃ biotransformation and clinical efficacy correlations in the treatment of APL
Dr. Zdenka Šlejkovec
- Biochemical correlates of autism spectrum disorders
Dr. Bogdan Kralj
- The influence and interactions of chromium and iron species in yeast cells
Dr. Radmila Milačič
- Impact of selenium on the yield of vegetables and crop plants
Asst. Prof. Vekoslava Stibilj
- The response of soil organic matter and natural ecosystems (primarily forests) to climate change
Dr. Polona Vreča
- Functional foods with polyphenol's antioxidants, plant proteins and trace elements.
Asst. Prof. Vekoslava Stibilj
- Ljubljansko barje - archaeological landscape in flux
Asst. Prof. Nives Ogrinc
- Carbon transport processes and mechanisms in forest ecosystems
Asst. Prof. Nives Ogrinc
- The influence of UV-B radiation to antioxidant content and distribution in cultivated plants
Asst. Prof. Vekoslava Stibilj
- Geochemical comparison of metal fluxes in industrial and volcanic environmental
Dr. Jože Kotnik
- Identification and remediation of pharmaceutical residues in effluent and surface waters
Asst. Prof. Ester Heath
- Nitrate migration in the plant-soil-water system
Asst. Prof. Sonja Lojen
- Biological methods for Hg monitoring
Prof. Milena Horvat
- The use of new materials from the recycled industrial products and building rubbles in civil engineering
Asst. Prof. Radmila Milačič
- The effect of nutrition (content of selenium and cadmium) and physical stress on the Se status of soldiers
Asst. Prof. Vekoslava Stibilj
- Harmonized and safety nutrition
Asst. Prof. Vekoslava Stibilj
- The comparison and development of new methods for determining the authenticity of oil in foodstuff
Asst. Prof. Nives Ogrinc
- The influence of climatic changes on the growth and responses of trees at the forest edge in Slovenia
Asst. Prof. Nives Ogrinc
- Port of Koper in the framework of sustainable development of the coastal region
Asst. Prof. Branko Koutić
- Territorial impact assessment of sectoral policies
Asst. Prof. Branko Koutić
- Development and preparation of new radiotherapeutic agents for targeted
Dr. Urška Repinc
- The influence of environmental change on the growth rate of oak (*Quercus vobur*) and larch (*Larix decidua*)
Asst. Prof. Nives Ogrinc
- Development of tools for management and analysis of the loads and influences on waters in the Sava and Soča catchments
Asst. Prof. Nives Ogrinc
- Identification of anomalies in radon transport caused by seismic activity
Asst. Prof. Janja Vaupotič
- Control of mercury emission and other elements in thermo power plants, cement production and other high temperature industrial processes
Prof. Milena Horvat
- Determination of geographical and botanical origin of honey
Dr. Marijan Nečemer
- Assessment of the environmental impact of military training ground krivolak with the aim of its ecological remediation
Asst. Prof. Sonja Lojen

RESEARCH PROGRAMS

- Modelling of structure-property relationships - QSAR-QSPR
Dr. Bogdan Kralj
- Cycling of nutrients and contaminants in the environment, mass balances and modeling of environmental processes and risk analysis
Prof. Milena Horvat
- Modeling and environmental impact assessment of processes and energy technologies
Dr. Borut Smodiš

NEW CONTRACTS

- Control of mercury and other trace element emissions in high temperature industrial processes
Esotech, d.d.
Prof. Milena Horvat
- Environmental radioactivity monitoring around the Žirovski vrh former mine area in 2007
RŽV, d.o.o.-Žirovski vrh Mine
Asst. prof. BorutSmodiš
- Systematic survey of working and living environments in 2007
Ministry of Health
Asst. prof. Janja Vaupotič
- Monitoring of the Slovenian sea environment with directives of Barcelon convention. Analysis of metals and organotin compounds in water, sediments and mussels
Ministry of the Environment and Spatial Planning
Asst. prof. Janez Ščančar
- Lease of the Hot cells facility
Arao-Agency for radwaste management
Asst. prof. BorutSmodiš
- Human Biomonitoring in Slovenia
Ministry of Health
Prof. Milena Horvat
- Soil gas radon potential on radon prone areas
Ministry of the Environment and Spatial Planning
Asst. prof. Janja Vaupotič

VISITORS FROM ABROAD

- Michael Beeston, University of Exeter, Great Britain, 1. 1. - 31.1.2007
- Prof. Stanley Lutts, Stephanie Lapaille, Unit of Plant Biology, Catholic University of Louvain, Belgium, 25. 1. 2007
- prof. Kazimerz Rožanski, Fakulteta za fiziko in nuklearne tehnike, Univerza za rudarstvo in metalurgijo Krakow, Krakow, Poland, 1. 2. 2007
- Ural Bekov Bolat, Al-Farabi Kazakh National University, Kazakhstan, 6. - 8. 3. 2007
- Lina Lofmark, University of Lund, Sweden, prof. Mark Hines, University of Massachusetts, USA, 15. 3. 2007
- Lea Kauppi, Mr. Campi, European Environment Agency, Finland, 18. 3. 2007
- Suzanne Wagner, fellowship Forschung Austria, Joanneum Research, Institute of Sustainable Techniques and Systems, Graz, Austria, 4.6. - 3.8. 2007
- dr. Sheena Nakou, Institute of Child's Health, Athens, Greece, 23. 4. - 28. 4. 2007
- Dr. Alfred Vidic, Zavod za javno zdravstvo FBiH, Sarajevo, Bosnia and Herzegovina, 17. 4. - 21. 4. 2007
- Nabil Benfaid, IAEA Fellowship, Tajora Nuclear Research Center, Tripoli, Libya, 12. 3. to 11. 7. 2007
- Prof. Paolo Zatta, CNR Institute for Biomedical technology, University of Padova, Italy, 10. 4. - 11. 4. 2007
- prof. Antonio Sacco, dr. Maria A. Brescia, BHT-05-08-013, University of Bari, Italy, 6. 5. - 9. 5. 2007
- Maria A. Arribere, AR-06-08/01, Centro Atomico Bariloche, Argentina, 10. 5. - 12. 5. 2007
- dr. Maria Angela de Barros Correia Menezes, CDIN/CNEN, Belo Horizonte, Brazil, 10. 5. - 19. 5. 2007
- Sergio Ribeiro Guevara, Laboratorio de Analisis por Activacion Neutronica, centro Atomico Bariloche, Argentina, 12. 5. - 9. 6. 2007
- prof. Trajče Stafilov, dr. Petre Makreski, Univerzitet Sv. Kiril i Metodij, Skopje, Macedonia, 21. - 25. 5. 2007
- dr. Lynn Walter, prof. dr. Stephen Hamilton, Michigan State University, Lansing, Kelly Umlauf, University of Michigan, Ann Arbor, USA, 21. 5. - 2. 6. 2007
- dr. Takashi Tomiyasu, dr. Akito Matsuyama, National Minamata Institute, 2. - 12. 10. 2006, dr. Ryusuke Imura, Kagoshima University, Japan, 24. 5. - 3. 6. 2007

19. dr. Henrik Andersen, Kamilla Hansen, BDK07-09-003, DTU Copenhagen, Denmark, 3. 6. - 30. 6. 2007
20. dr. Salvatore Giammanco, BI-IT-05-08-026, Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Catania, Catania, Italy, 18. 6. - 28. 6. 2007
21. Jadranka Barešić, Institut Rudjer Bošković, Zagreb, Croatia, 2. - 6. 7. 2007
22. Ryszard Haber, Jadwiga Mazur, Elzbieta Kochowska, Krzysztof Kozak, The Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences, Natural Radioactivity Laboratory, BI-PL/05-07/001, Krakow, Poland, 9. 7. - 22. 7. 2007
23. dr. Adriana Hulsmann, KIWA Research, Netherlands, 10. 7. 2007
24. Joulien Heroult, University of Pau, France, BI-FR-07-PROTEUS 006, 15. 7. - 31. 7. 2007
25. Juan Vasquez Navarra, IGME, Instituto Geologico y Minero de Espana, Madrid, Spain, 1.7. - 15. 8. 2007
26. prof. Drasch, Institute of Forensic Medicine, dr. Stephan Böse O'Reilly, Beate Lettmeier, UMIT, Institute of Public Health, Austria, 27. 8. - 28. 8. 2007
27. Milena Taseska, BI-MK-07-08-023, Univerzitet Kiril i Sveti Metodij, Skopje, Macedonia, 30. 9. - 23. 10. 2007
28. Darya Bairasheuskaya, Department of Environmental Monitoring, International Sakharov Environment University, Minsk, Belarus, 14. 9. - 31.12.2007
29. Olja Jotanović, Prirodno-matematički fakultet, Banja Luka, Bosnia and Herzegovina, 22. 10. - 21. 12. 2007
30. Dennis Kpakpo Adotei, Ghana Atomic Energy Commission, Accra, Ghana, 5. 11. 2007 - 1. 5. 2008
31. Snežana Milošević, Skupština opštine Bujanovac, Vranje, Vinča, Serbia, 15.11. 2007 - 15. 3. 2008
32. Ms. Marlene Klein, University of Pau, France, 25. 11. - 1. 12. 2007

STAFF

Researchers

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3. Asst. Prof. Ester Heath
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6. Asst. Prof. Zvonka Jeran
7. Asst. Prof. Branko Kontić***
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22. Dr. Darja Mazej
23. Dr. Urška Repinc
24. Dr. Polona Vreča
25. Dr. Boris Zmazek***

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26. Miha Avberšek, B. Sc.
27. Tinkara Bučar, B. Sc.
28. Petra Cuderman, B. Sc.
29. Marinka Gams Petrišič, B. Sc.
30. Darija Gibičar, B. Sc.
31. Asta Gregorič, B. Sc.
32. Rožle Jakopič, B. Sc.
33. David Kocman, B. Sc.
34. Davor Kontič, B. Sc.
35. Tadeja Milivojevič Nemanič, B. Sc.
36. Tanja Mrak, B. Sc.
37. Simona Murko, B. Sc.
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39. Marko Štrok, B. Sc.
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DEPARTMENT OF AUTOMATION, BIOCYBERNETICS AND ROBOTICS E-1

Our research brings together different fields of automatics, robotics, biocybernetics, kinesiology and environmental medicine. Most of the research topics are connected to the so-called “movement of man and machine” and its connection and interaction with the environment. The aim is to make available advanced knowledge, as well as to develop and transfer systems and technologies to our customers in industry, medicine and sport.

The main directions of research in the past year were humanoid robotics, the integration of mobility and manipulation in industrial and service robotics, studies of human physiology in extreme environments, the evaluation of protective equipment, the development of biomedical devices and methods, and the robotics and automation of industrial manufacturing.

In the area of humanoid robotics we continued with our research on the realization of cognition on humanoid robots. This work was initiated by our participation in the FP6 Integrated Project “Perception, Action, and Cognition through Learning of Object-Action Complexes” (PACO+). PACO+ aims at the design of a cognitive robot that is able to develop perceptual, behavioral and cognitive categories in a measurable way and communicate and share these with humans and other artificial agents. In 2007 we concentrated on the learning of action knowledge that enables the robot to accomplish a task in any given configuration of the external world. Another important topic was the learning of object representations using active vision and robotic manipulation. We implemented the algorithms on a Mitsubishi PA-10 robot. Next, we have started working on primitive motions for object pushing. The idea is to teach a robot how an object moves when pushed in a certain direction and then the robot should use this knowledge to move objects on a prescribed trajectory. The robot should learn this task only by exploration and imitation in a cognitive fashion.

In 2007 we completed the project “Learning object-action descriptions and active object recognition by a humanoid with foveated vision”, which was carried out in collaboration with ATR Computational Neuroscience Laboratories, Kyoto, Japan. We continued collaborating with ATR in the frame of the bilateral project “Goal-directed sensorimotor primitives for building object representations on a walking humanoid robot”. In this project we developed new algorithms for the figure-ground discrimination of previously unknown objects that are manipulated by the robot.

In 2007 we obtained a humanoid robot called HOAP-3 Fujitsu, which will be used as a testing platform for our research on humanoid robotics. We have developed an interface for the robot controller, which makes it possible to control the HOAP robot from the Matlab and Matlab/Simulink programming environments.

In the field of the kinematics and dynamics of the human body we continued our research on the energy-efficient motion of human and robot mechanisms. We redesigned and improved the humanoid robotic mechanism by reducing backlash in the gears and by changing the gears in the joints. Next, we optimized the vertical jump, the broad jump and the running of the humanoid robotic mechanism in the simulation environment. On the basis of the optimization results we performed a series of experiments on a real humanoid robotic mechanism. We experimentally confirmed the hypothesis that we set in the biomechanical analysis of the human vertical jump, stating that biarticular links and elastic tissues significantly influence the effectiveness of fast movements.

We established an original concept to effectively transfer human motion to a humanoid robot by using a closed-loop system setup, where a human subject actively controls the humanoid robot motion. While controlling the humanoid robot through an adaptive motion controller, visual and mechanical feedback loops are to be provided from the humanoid robot to the human subject. We demonstrated our concept by effectively transferring the motion from the human subject to the real humanoid robot. For that we designed an adaptive motion controller based on an efficient machine-learning technique called the Radial Basis Function Network.



Head:
Dr. Leon Žlajpah

We showed that dynamic, goal-directed actions can be synthesized by applying locally weighted regression to the library of example movements, where each of the example movements is known to fulfil the task in one particular situation.



Figure 1: Object learning on the Armar III humanoid robot (Experiments made at the University of Karlsruhe)

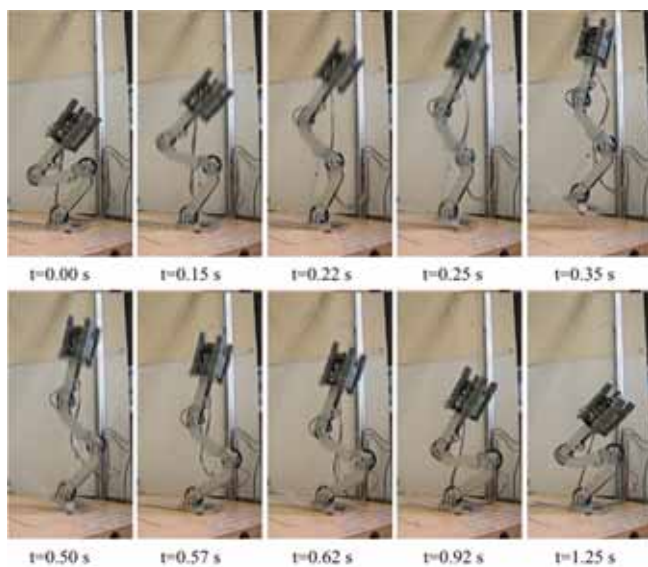


Figure 2: Jumping robot mechanism during a high jump using elastic biarticular tendons

development and testing of individual subsystems in the laboratory environment, we have built a simulator based on virtual reality technology.

We have collaborated with the Droga Kolinska Company for several years. In the past year we have begun a research-and-development project aimed at a major rearrangement and upgrade of a tea-production plant for a national food-production society. As a result of past automations the company has been able to achieve lower production costs, and as a consequence they have taken over the complete tea production for a foreign company. The expansion required large changes and updates to the facility. To achieve a flexible production facility for the concurrent production of different tea products functional improvements to the supervisory and control system

To achieve a flexible production facility for the concurrent production of different tea products functional improvements of the supervisory and control systems were needed, together with tight integration with the manufacturing execution and enterprise resource planning levels.

were needed together with tight integration of the manufacturing execution and enterprise resource planning levels.

With the support of the Olympic Committee of Slovenia we developed a unique normobaric hypoxic facility in the newly constructed Olympic Nordic Centre in Planica. The developed facility is capable of maintaining simulated altitudes of 5400 meters above sea level in 10 double hotel rooms and in a laboratory/training room. In addition, the basketball court can also be maintained at 2800 meters above sea level. In parallel with the technical development of the hypoxic facility, we also conducted a

physiological study to evaluate different protocols for altitude acclimatization: intermittent hypoxic training, sleep low and train high, and train high and sleep low. Of the three methods, sleep high and train low proved to be the most efficient in improving exercise performance. The hypoxic facility is now being used by elite athletes wishing to incorporate hypoxic training in their overall training regime. The facility is also being used by alpinists who wish to conduct their altitude acclimatization in Slovenia, prior to embarking on a high altitude expedition in the Himalayas. This project was also sponsored, in part, by the Ministry of Defence, who are interested in the altitude acclimatization of military personnel joining international peace-keeping missions in regions of high altitude.



Figure 3: Robot skier mechanism and simulation of skiing in a virtual environment

This project has also culminated in an industrial partnership with B-Cat (The Netherlands), which now markets these hypoxic facilities. A similar facility has been developed in Rogla Terme for the Unior Zreče Company, where six sleeping chambers were equipped with high-altitude systems.

The development of thermal manikins continues to be a successful research-and-development programme. Together with the Centre d'Etudes de Physiologie Appliquee at the CNRS in Strasbourg we developed several new sweating thermal manikins: torso, head and hand manikins. Also our gait simulator for testing footwear has been improved. A new computer-control unit allows the user easier and more accurate testing. Our manikins are now being used by industrial laboratories, such as Decathlon (France), Gore & Associates (USA), Armasuisse (Switzerland), to name but a few, in

the design and evaluation of clothing items (footwear, handwear, helmets, clothing ensembles, etc). Physiological research conducted in collaboration with colleagues at the University of Wollongong (Australia) has demonstrated the substantial variation in the sweating responses among different body regions. This information regarding regional patterns of sweating is now being incorporated into our sweating thermal manikins.

Within the framework of a Knowledge for Security and Peace grant administered by the Ministry of Defence of the Republic of Slovenia, we assisted Alpina d.d. in developing a new generation of military boots for winter and summer conditions. The developed footwear is the result of numerous laboratory and field trials.

The prevention of cold injuries continues to be one of several research foci in the biocybernetic group. Together with colleagues from Brock University (St. Catherines, Ontario, Canada) we continue to investigate methods of enhancing the cold-induced vasoconstriction response (CIVD), and thus minimizing the risk of cold injury to fingers and toes. Of the many methods investigated, exercise training and altitude acclimatization appear to improve certain traits of this response. The mechanism for this observed effect is the focus of future research.

Motion sickness is a debilitating condition. Working with colleagues from the Swedish Defence Research Agency at the Karolinska Institutet (Stockholm, Sweden) a major study has been completed, investigating the effect of anti-motion sickness pharmacological agents on thermoregulatory responses during cold-water immersion.

The bedrest research programme initiated by JSI personnel in collaboration with personnel from the Swedish Defence Research Agency at the Karolinska Institutet (Stockholm, Sweden) in 2001 continues to thrive. The study conducted in 2007 was conducted in collaboration with the University of Primorska (Koper), and was funded by the Italian Space Agency. Projects conducted by 10 laboratories focused mainly on the issues of osteoporosis and muscle atrophy.

Testing with our sweating, thermal foot manikins helped to develop a new generation of military boots for winter and summer conditions for the Slovenian Army.



Figure 4: Training during altitude acclimatization in the new Nordic Olympic Centre in Planica

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1. V. Krueger, D. Kragic, A. Ude, and C. Geib, Meaning of action: A review on action recognition and mapping, *Advanced Robotics*, 21(13): 1473–1501, 2007.
2. Mekjavic I.B., Eiken O. Invited review: Contribution of thermal and nonthermal factors to the regulation of body temperature in humans. *Journal of Applied Physiology* 100 (2006): 2065–2072.
3. Andrej Gams, Leon Žlajpah, Jadran Lenarčič. Imitating human acceleration of a gyroscopic device. *Robotica*, 2007, vol. 25, str. 501–509.
4. Bojan Nemeč, Leon Žlajpah, Damir Omrčen. Comparison of null-space and minimal null-space control algorithms. *Robotica*, 2007, vol. 25, no. 4, str. 337–344.
5. Damir Omrčen, Leon Žlajpah, Bojan Nemeč. Compensation of velocity and/or acceleration joint saturation applied to redundant manipulator. *Robot. auton. syst.*. 2007, vol. 25, no. 4, str. 337–344

Patents granted

1. 22319 (application 200600122): Procedure and optical device for image showing visible from every direction. Lahajnar Leon, Leskovec Janez, Lahajnar Franci; KOLEKTOR GROUP Vodenje in upravljanje družb d.o.o.
2. Aleš Ude, Gordon Cheng, Kai Welke, Joshua G. Hale
A new way of learning about objects for visual recognition by manipulation : Japanese patent no. 2007-096733
Japan Patent Office, 2007.

Awards and appointments

1. Mitja Babič, Borut Lenart, Jože Opeka, Igor Mekjavič, Bogomir Vrhovec: The 2007 Puh award for achievements in R&D, and for applying the results of scientific research to industrial practice; particularly the development of a sweating thermal foot manikin with a gait simulator, Government of the Republic of Slovenia
2. Damir Omrčen: The article Sensorimotor Processes for Learning Object Representations was defined as one of three best articles of the conference Humanoids 2007, Pittsburgh, ZDA, proposer: Prof. James Kuffner

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B. SC. THESIS

1. Marija Trampuž: Public relations - target groups of the Jožef Stefan Institute (JSI), public research institution (Marjan Blažič)

INTERNATIONAL PROJECTS

1. Innovation Relay Centre of Slovenia
Si-IRC-04-08
6. FP
510419 (IRC 6)
Alice Wu, European Commission, DG Enterprises and Industry Innovation Policy D/2 „Support for Innovation“, Office BREV 06/073, Brussels, Belgium
Dr. Leon Žlajpah, Prof. Peter Stegnar
2. Perception, Action & Cognition through Learning of Object-Action Complex
PACO-PLUS, 6. FP
027657
EC; Universitaet Karlsruhe (TH), Karlsruhe, Germany
Dr. Aleš Ude
3. European Robotics Network
EURON, 6. FP, 507728
EC; Kungliga Tekniska Högskolan, Stockholm, Sweden
Prof. Jadran Lenarčič
4. Manikins for Decathlon
Philippe Pieri, Centre National de la Recherche Scientifique CNRS, Centre d'Etudes de Physiologie Appliquée, Strasbourg, Francija
Dr. Leon Žlajpah
5. Goal-directed Sensorimotor Primitives for Building Object Representations on a Walking Humanoid Robot
0114061102001
Dr. Mitsuo Kawato, Advanced Telecommunications Research Institute International, Computational Neuroscience Laboratories, Department of Humanoid Robotics and Computational Neuroscience, HIKARIDAI, Seika-cho, Soraku-gun, Kyoto, Japan
Dr. Ude Aleš

6. Learning Object-action Descriptions and Active Object Recognition by a Humanoid with Foveated Vision
SLO-JPN
Prof. Cheng Gordon, Advanced Telecommunications Research Institute International, Computational Neuroscience Laboratories, Department of Humanoid Robotics and Computational Neuroscience, Hikaridai, Seika-cho, Soraku-gun, Kyoto, Japan
Dr. Aleš Ude
7. Sweating Thermal Foot System
Dr. Volkmar T. Bartels, Prof. K. H. Umbach, Bekleidungsphysiologisches Institut Hohenstein e.V., Department of Clothing Physiology, Boennigheim, Germany
Dr. Leon Žlajpah
8. High-Altitude Instalation in ŠC Planica
06/01-2007/JSI
René M. J. Luyten, b-Cat BV, Tiel, The Netherlands
Prof. Igor Mekjavić
9. High-Altitude Instalation in Rogla Terme
B38607001B/CJSI
René M. J. Luyten, b-Cat BV, Tiel, The Netherlands
Dr. Leon Žlajpah
10. Testing with Flame Manikin
JSI Order 06-07-1
James R House BSC (Hons) PhD CBiol MIBiol, Flaming Hot Physiology Ltd, Alverstoke, Gosport, Great Britain
Prof. Igor Mekjavić

R & D GRANTS AND CONTRACTS

1. Controlled internal combustion engine
Dr. Jan Babič
2. System for automatic supervision and control of a production line for simultaneous production of different products
Dr. Leon Žlajpah
3. High-altitude acclimatization
Prof. Igor B. Mekjavić
4. Protective systems for warrior
Prof. Igor B. Mekjavić

RESEARCH PROGRAM

1. Automation, robotics and biocybernetics
Prof. Jadran Lenarčič

NEW CONTRACTS

1. Cofinancing of the "Altitude acclimatisation" project
Olympic committee of Slovenia
Igor Mekjavić
2. Functional restructuring of a supervisory and control system for an automated food production line
Droga Kolinska d.d.
Anton Ružič

VISITORS FROM ABROAD

1. Viktor Candás, Centre National de la Recherche Scientifique-CNRS, Paris, France, 23.1. – 26. 1. 2007
2. dr. Gordon Cheng, ATR Computational Neuroscience Laboratories, Dept. of Computational Neuroscience and Humanoid Robotics, Kyoto, Japan, 12. 5. – 15. 5. 2007

3. Jim House, Flaming Hot Physiology Ltd, Gosport, Great Britain, 9. 2. – 17. 2. 2007
4. dr. Duško Katič, Mihailo Pupin Institute, Belgrade, Serbia, 9. 4. – 15. 4. 2007
5. Michail Keramidas, Athens, Greece, 13. 1. – 30. 6. 2007
6. Rene Luyten, B-Cat, Tiel, The Netherlands, 5. 4. and 6. 4. 2007, 14. 5. – 17. 5. 2007 and 18. 6. – 21. 6. 2007
7. dr. Aleksandar Rodič, Mihailo Pupin Institute, Belgrade, Serbia, 9. 4. – 15. 4. 2007
8. prof. Nigel Taylor, University of Wollongong, New South Wales, Australia, 8. 4. – 14. 4. 2008

STAFF

Researchers

1. Dr. Ladislav Lenart
2. Prof. Igor Mekjavić
3. Dr. Bojan Nemeč
4. Dr. Anton Ružič
5. Dr. Aleš Ude

6. Dr. Leon Žlajpah, Head

Postdoctoral associates

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8. Dr. Damir Omrčen
9. Dr. Martin Tomšič

Postgraduates

10. Mitja Babič, B. Sc.

11. Tadej Debevec, B. Sc.
12. Andrej Gams, B. Sc.
13. Blaž Hajdinjak, B. Sc.
14. Leon Lahajnar, B. Sc.
15. Eva Stergaršek Kuzmič, B. Sc.
16. Daniel Wolowske, M. Sc.

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17. Andrej Kos, B. Sc.
18. Borut Lenart, B. Sc.
19. Bogomir Vrhovc, B. Sc.

Technical and administrative staff

20. Dušan Filipič
21. Jožef Opeka
22. Marija Trampuž, B. Sc., secretary
23. Janez Zalar

DEPARTMENT OF SYSTEMS AND CONTROL

E-2

The Department of Systems and Control is engaged in research, development, applications and education across various areas of control technology. Its mission is “to bridge the gap between theory and practice”. Hence, the research activities are relatively application oriented, and the content of the work is closely related to the needs of production companies. The activities of the department are focused on the research of new methods and algorithms for automatic control, the development of procedures and tools to support the design and construction of control systems, the development of specific measurement and control modules, and the development and construction of complete systems for the control and supervision of machines, devices and industrial processes.

Basic and applied research

The basic and applied research during 2007 was devoted to four sub-areas: the analysis and control of complex systems and processes, fault detection and isolation, computer-integrated production control, and advanced implementation technology.

In the sub-area **analysis and control of complex systems and processes** our work was devoted to the development of some general-purpose methods. The research efforts in dynamic systems modelling of Gaussian process models were focused on methodology and the incorporation of prior knowledge in models (Fig.1). Gaussian process models were further used for control design in various control algorithms, among them in explicit model predictive control. In the area of predictive control the work was focused on parametric predictive controllers. Parametric optimization is used to shift the computational burden, associated with online optimization, offline.

In the control loop it is only necessary to select the active linear control law from a table (Fig.2). This work was closely related with the EU 6FP CONNECT. We were also active in the research of the improved supervision of online identification of an adaptive controller by using pattern-recognition techniques and hybrid systems theory, as well as in the optimal tuning of controllers where a new “equalization” method was proposed for the tuning of PID and multivariable controllers.

New control methods and algorithms were also being developed on various specific problem domains. Within the international project PRISM a model of the polymerisation process was developed. The model will be used for process optimisation, with the aim to shorten the batch cycle. Within the international project PEGASE, a system for the automatic landing of aircraft and helicopters is being developed, which is completely autonomous and does not depend on any kind of infrastructure or equipment located outside the aircraft. The idea is to guide the aircraft using images, acquired by the camera, installed on the aircraft. In the control of wastewater-treatment processes, different alternatives to control nitrification and pre- and post-denitrification processes based on nutrient sensors were evaluated by simulation.

In the sub-area of **fault detection and isolation** work has been continued on the problem of spectral reconstruction from short time series by means of the Filter-Diagonalization method. Monte Carlo analysis revealed that the high resolution of the reconstructed spectral content could be achieved in the condition of short observation times and noise in the signal. Using the example of a bearing fault on an electrical motor, the algorithm demonstrated fast and accurate tracking of the instantaneous frequencies of the signal. Part of the activities was devoted to the development of algorithms for the supervision of processes and product quality on the basis of novel statistical modelling approaches. For the case of Gaussian process models, a fault-detection algorithm has been derived by making use of statistical decision making.



Head:
Prof. Stanislav Strmčnik

The Department of Systems and Control is engaged in research, development, applications and education across various areas of control technology.

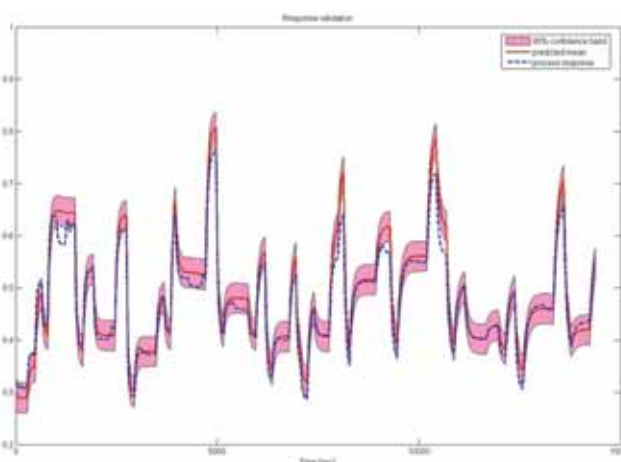


Figure 1: Comparison of a real-process response and its Gaussian process model.

The basic and applied research during 2007 was devoted to four sub-areas: the analysis and control of complex systems and processes, fault detection and isolation, computer-integrated production control, and advanced implementation technology.

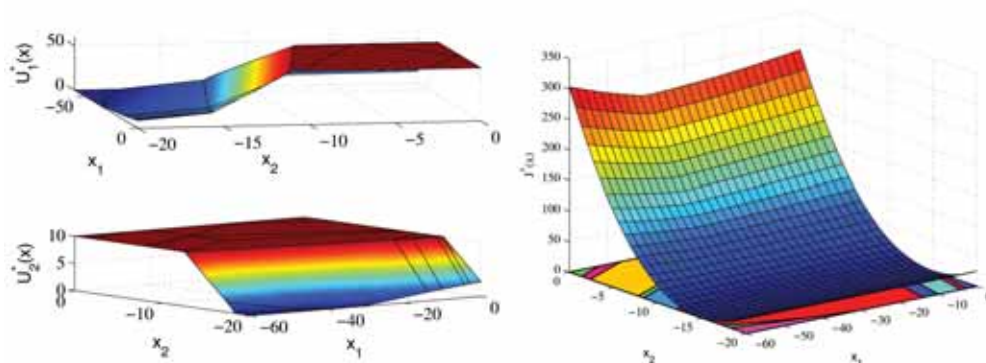


Figure 2: Surfaces of control signals and the optimal value function of a parametric predictive controller

In co-operation with the Centre for Tribology and Technical Diagnostics, University of Ljubljana, we contributed to the development of a laboratory test bed and experimental environment for the diagnosis of electrical machines and drives. The development of diagnostic algorithms based on the analysis of vibrations, electrical current and oil parameters is under way.

In cooperation with the Slovenian Ministry of Defence four projects in the area of fuel-cell-based system applications and the development of subsystems for fuel-cell power units are being performed.

A part of the work related to this sub-area was devoted to the research of methods that enable an assessment of the state of a living organism, based on the level of coupling among oscillatory physiological signals, like ECG, EEG, respiratory effort, etc. In the past year we finished developing the measurement system and started with measurements on humans and rats. The work has been carried out in close connection with the international project BRACCIA.

Our research in the sub-area of **computer-integrated production control** was concentrated on the design and verification of a hierarchical production-control system. A concept for production control, using a reduced set of production-process parameters, was developed (Fig. 3), together with the corresponding control algorithms. For the production control of a batch-polymerization plant in the company Mitol, three algorithms have been evaluated: production control based on look-up tables, predictive control based on a simplified production model and production control based on an expert system. A number of simulation runs have been carried out in order to validate these control algorithms.

In the area of **advanced implementation technologies** a part of the activities was devoted to the development of a rapid-prototyping tool for the design and implementation of control algorithms. In this frame the identification of the parameters of the continuous second-order process model with time-delay has been included. The model has been used within an integrated Smith predictor.

The second part was related to methods and tools for control SW development. A more thorough definition was elaborated for the syntax and semantics of the domain-specific modelling language ProcGraph, which was previously developed in our department.

To fulfil the needs for the development of new electronic devices, further work on the environment that will enable the design of embedded control and digital signal processing systems, based on the ARM core microprocessors, was continued.

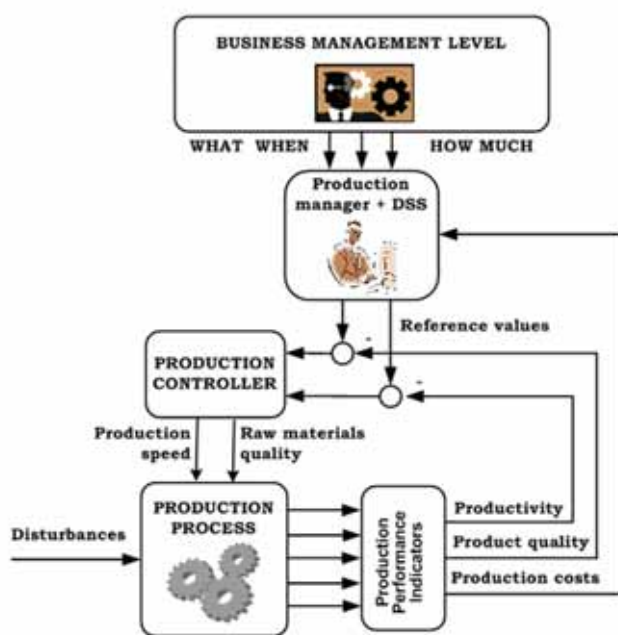


Figure 3: Hierarchical production control scheme for the polymerization plant in Mitol d.d.

Some members of the department are giving lectures and practical courses at the Faculty of Electrical Engineering, University of Ljubljana, the Faculty of Logistics, University of Maribor, the University of Nova Gorica, and the “Jožef Stefan” International Postgraduate School.

R&D projects for industry and other users

In cooperation with the **Slovenian Ministry of Defence** four projects in the area of fuel-cell-based system applications and the development of subsystems for fuel-cell power units are being performed (Fig. 4). In the frame of fuel-cell applications we were developing a fuel-cell-based auxiliary power-supply system, for increasing the autonomy of a military vehicle, and a demonstrational prototype of a mobile cogeneration fuel-cell-based system. In the frame of fuel-cell subsystems development we are a partner

involved in the design of a ceramic fuel reformer for PEM-type fuel cells and in the development of the experimental laboratory set-up for the testing and validation of various subsystems for PEM fuel cells.

Apart of the above-mentioned work, we were also very active in R&D projects for industry. For the company **DOMEL d.d.** we were working on upgrading the previously developed automatic diagnostic system for the end-quality control of electrical motors, and on the development of a control system for a gas- and air-delivery system for a fuel cell. For the company **GOAP** a new algorithm for calculating the room-temperature set-points in buildings was developed.

A new tool called PLCbatch (Fig. 5) for recipe-based batch-process control was developed in cooperation with the company **INEA**, based on the experience and results of our previous work on the development of the prototype tool LiteBatch. The new tool opens a new market segment of PLC-based batch-process control. Currently, with the aid of this tool, a process-control system in the paint-producing company **Color** is being developed. For the company **Danfoss-Trata**, hardware and software has been developed for the control of continuous and three-point valves. The implemented algorithms enable intelligent behaviour of the valves. In addition, some smaller projects were carried out for our traditional partners: the **Domžale-Kamnik wastewater-treatment plant**, and the **Cinkarna-Celje** chemical works.

A substantial part of our work was also devoted to final activities within the projects of the **Centre of Excellence for Advanced Control Technologies** (which includes 15 industrial and four academic partners), which is coordinated by our department, and on a large project (26 partners) entitled **“Advanced Control Technologies for Improving Competitiveness”**, where we also played a substantial role in the coordination. The projects were co-financed by European structural funds.

Education and training activities

Some members of the department are giving lectures and practical courses at the Faculty of Electrical Engineering, University of Ljubljana, the Faculty of Logistics, University of Maribor, the University of Nova Gorica, and the “Jožef Stefan” International Postgraduate School. They also act as supervisors of M.Sc. and Ph.D. students. Special care was given to post-qualification training for engineers from industry. In 2007, three one-week courses were organized. These courses were organized in close cooperation with the Information Technologies Knowledge Transfer Centre at the Jožef Stefan Institute.

Some outstanding publications in the past three years

1. Gerškšič, Samo, Dolanc, Gregor, Vrančič, Damir, Kocijan, Juš, Strmčnik, Stanko, Blažič, Sašo, Škrjanc, Igor, Marinšek, Zoran, Božiček, Miha, Stahaki, Anna, King, Robert E., Hadjinski, Mincho B., Boshnakov, Kosta. Advanced control algorithms embedded in a programmable logic controller. *Control eng. pract.*. [Print ed.], 2006, vol. 14, no. 8, pp. 935–948.
2. Stare, Aljaž, Vrečko, Darko, Hvala, Nadja, Strmčnik, Stanko. Comparison of control strategies for nitrogen removal in an activated sludge process in terms of operating costs: a simulation study. *Water res. (Oxford)*. [Print ed.], 2007, vol. 41, no. 9, pp. 2004–2014.
3. Benko, Uroš, Petrovčič, Janko, Juričič, Đani, Tavčar, Jože, Rejec, Jožica. An approach to fault diagnosis of vacuum cleaner motors based on sound analysis. *Mech. syst. signal process.*, 2005, vol. 19, pp. 427–445.

The most important technological achievements in the past three years

1. A control system for a magneto-focused plasma annealer (Gregor Dolanc, Samo Gerškšič)
2. A series of systems for the quality control of vacuum-cleaner motors (Janko Petrovčič, Gregor Dolanc, Bojan Musizza, Đani Juričič, Dejan Tinta, Uroš Benko, Stane Černe, Janez Grom, Miro Štrubelj)



Figure 4: Demonstration of the 7kW fuel-cell based power unit

Our paper on advanced control algorithms (listed under outstanding publications) was, in the first quarter of 2007, second, and, in the second quarter of the year, first on the list of the “Top 25 hottest articles” of the journal *Control Engineering Practice*.

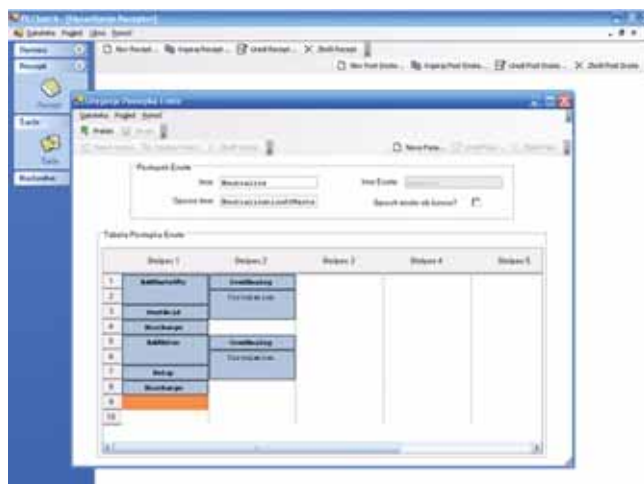


Figure 5: User interface of the PLCbatch tool (unit procedure recipe editing window)

Organization of conferences, congresses and meetings

1. Production management and information systems: continuing education (specialisation) course in Control Technology, Ljubljana, January 29 – February 2, 2007
2. Automation and information technology projects: continuing education (specialisation) course in Control Technology, Ljubljana, March 26 – 30, 2007
3. Building blocks for computer automation: continuing education (specialisation) course in Control Technology, Ljubljana, October 22 – 26, 2007

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Application of Gaussian processes for black-box modelling of biosystems
In: ISA trans., Vol. 46, no. 4, pp. 443-457, 2007.
2. Gregor Bavdaž, Juš Kocijan
Fuzzy controller for cement raw materials blending
In: Trans. Inst. Meas. Control, Vol. 29, no. 1, pp. 17-34, 2007.
3. Gregor Dolanc, Samo Gerškšič, Juš Kocijan, Damir Vrančič, Stanko Strmčnik, Miha Božiček, Zoran Marinšek, Igor Škrjanc, Sašo Blažič
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Predictive control of a gas-liquid separation plant based on a Gaussian process model
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Evaluation of fire protective garments using model-based estimation of burn injuries
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In: Proceedings of the 6th EUROSIM Congress on Modelling and Simulation. Vol. 2, Full papers, 6th EUROSIM Congress on Modelling and Simulation, Ljubljana, Slovenia, 9-13 September 2007, Borut Zupančič, ed., Rihard Karba, ed., Sašo Blažič, ed., Vienna, AGRESIM, ARGE Simulation News, Vienna University of Technology, cop. 2007, 8 str..
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PUBLISHED CONFERENCE PAPERS

Invited Paper

1. Stanko Strmčnik
Strategija razvoja na področju tehnologije vodenja v Sloveniji - načrti in realizacija
In: Zbornik pete konference Avtomatizacija v industriji in gospodarstvu, 11. in 12. april 2007, Maribor, Slovenija, Boris Tovornik, ed., Nenad Muškinja, ed., Maribor, Društvo avtomatikov Slovenije, 2007, pp. 1-6.

Regular Papers

1. Fernando Aller, Gregor Kandare, L. Filipe Blázquez, Dolores Kukanja, Vladimir Jovan, Michael C. Georgiadis
Model-based optimal control of the production of polyvinyl acetate
In: Conference CD(EFCE Event, No. 669), European Congress of Chemical Engineering ECCE - 6, Copenhagen 16-20 September 2007, Rafiqul Gani, ed., Kim Dam-Johansen, ed., Lyngby, Technical University of Denmark, Department of Chemical Engineering, 2007, 20 str..

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1. Kristjan Ažman: Dynamic systems identification with Gaussian processes (Juš Kocijan)
2. Uroš Benko: Fault diagnosis of technical systems based on modern signal processing techniques (Dani Juričić)
3. Aljaž Stare: Optimal control of nitrogen removal in a biological wastewater treatment plant (Stanko Strmčnik)

B. Sc. Theses

1. Aleš Bajc: Application of programme module Scicos for graduate in engineering and management (Juš Kocijan)
2. Jernej Bratina: Graphic user interface for rolling line supervisory control (Juš Kocijan)
3. Tomaž Lukman: Model driven engineering in the domain of industrial control systems
4. Valentin Simonič: The assessment of system antropocentricity with dual design method for the control of neutralisation batch process (Juš Kocijan)
5. Igor Žiberna: Assembly and control design for hard coating assembly line (Juš Kocijan)

INTERNATIONAL PROJECTS

1. Design of Advanced Controllers for Economic, Robust and Safe Manufacturing Performance
CONNECT, 6. FP, COOP-CT-2006, 031638
EC, Dr. Constantinos Pantelides, Process Systems Enterprise Limited, London, Great Britain
Dr. Samo Gerkišič, Dr. Vladimir Jovan
2. HelicoPter and aEronef naviGation Airborne System Experimentations
PEGASE, 6. FP, AST5-CT-2006-030839
EC; Bruno Pattin, Claire Lallemand, Dassault Aviation, Paris, France
Prof. Stanko Strmčnik, Dr. Gregor Dolanc
3. Towards Knowledge - Based Processing Systems
PRISM, 6. FP, MRTN-CT-2004-512233
EC; Imperial College of Science Technology and Medicine, London, Great Britain
Dr. Gregor Kandare
4. Explicit Nonlinear Model Predictive Control based on Gaussian Process Models
Prof. Alexandra Grancharova, Institute of Control and System Research, Bulgarian Academy of Sciences, Sofia, Bulgaria
Prof. Juš Kocijan
5. Bayesian Decision Making to support Change Detection in Complex Manufacturing Systems
BI-CZ/07-08-011
Ing. (Dipl.-Eng.) Phd Tatiana Valentine, Department of Adaptive Control, Institute of Information Theory and Automation, Prague, Czech Republic
Prof. Đani Juričič
6. Analysis, Diagnosis and Control of Distributed Nonlinear Process Systems
BI-HU/06-07/006
Sc. Dr. Katalin Hangos, Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest, Hungary
Prof. Đani Juričič
7. On-line Monitoring and Fault Diagnosis of Industrial Systems
BI-MK/07-08-018
Prof. Mile Stankovski, Faculty of Electrical Engineering, Skopje, The Republic of Macedonia
Prof. Đani Juričič
8. 12 Channel Measurement System Cardio&Brain Signals and Set of Sensors and Electrodes
Ullevål Universitetssykehus, Oslo, Norway
Dr. Janko Petrovčič
9. Design of PID Controllers: Interchange of Technology and Experience - Second Part
BI-PT/06-07-005
Asst. Prof. José Paulo de Maura Oliveira, Engineering Department, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal
Asst. Prof. Damir Vrančič
10. Building Virtual Communities for Research and Education in Automation and Control
BI-SK/05-07-009
Prof. Mikuláš Huba, Slovak University of Technology in Bratislava, Bratislava, Slovakia
Asst. Prof. Damir Vrančič
11. 12 Channel Measurement System Cardio&Brain Signals and Set of Sensors and Electrodes
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Dr. Janko Petrovčič

12. 12 Channel Measurement System Cardio&Brain Signals and POF to USB Converter
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R & D GRANTS AND CONTRACTS

1. Design of fault detection and isolation systems with application to quality assessment of electrical motors
Asst. Prof. Đani Juričič
2. An intelligent system for condition monitoring of rotating machinery
Asst. Prof. Đani Juričič
3. Optimization of HVAC systems using dynamic models
Prof. Dr. Stanislav Strmčnik
4. Rapid prototyping of advanced control algorithms in industrial environment
Asst. Prof. Damir Vrančič
5. Early detection of lung cancer in workers with asbestos disease
Asst. Prof. Đani Juričič
6. Fuel cell based auxiliary power system for autonomous operation of military vehicles
Dr. Janko Petrovčič

RESEARCH PROGRAM

1. Systems and control
Prof. Dr. Stanislav Strmčnik

NEW CONTRACTS

1. Design and implementation of the 12 channel measurement system - Cardio&Brain
University of Ljubljana
Dr. Janko Petrovčič
2. Design of electronic for intelligent valve drive
Danfoss Trata d.o.o., Ljubljana
Asst. Prof. Damir Vrančič
3. Mobile test laboratory with fuel cell power unit
Domel, d.d., Železniki
Dr. Vladimir Jovan
4. Development of demonstration prototype of mobile cogeneration fuel cell based system for military purposes
Inea d.o.o., Ljubljana
Dr. Vladimir Jovan
5. Development of demonstration prototype of mobile cogeneration fuel cell based system for military purposes
Domel, d.d., Železniki
Dr. Vladimir Jovan
6. Design and realisation of a control module
Domel, d.d., Železniki
Dr. Janko Petrovčič

VISITORS FROM ABROAD

1. prof. José Paulo de Maura Oliveira, Engineering Department, University of Trás-os-Montes e Alto Douro, Campus Universitário, Vila Real, Portugal, 20. - 27.7. 2007
2. prof. Mikuláš Huba, Slovak University of Technology in Bratislava, Bratislava, Slovakia, 19. 8. - 2. 9. 2007
3. dr. Pavel Ettler, Compureg Plzen, Plzen, Czech Republic

4. Peter Kurcik, Slovak University of Technology in Bratislava, Bratislava, Slovakia, 19. 8. - 2. 9. 2007
5. dr. Gabor Szederkenyi, Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest, Hungary, 9. - 15. 9. 2007
6. dr. Csaba Fazekas, Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest, Hungary, 9. - 15. 9. 2007
7. prof. David J. Murray-Smith, University of Glasgow, Department of Electronics and Electrical Engineering, Glasgow, Scotland, 11.9.2007.

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16. *Dr. Uroš Benko**, left 01.10.2007*

17. Matej Gašperin, B. Sc.
18. Tomaž Lukman, B. Sc.
19. Satja Lumbar, B. Sc.
20. Bojan Musizza, B. Sc.
21. Boštjan Pregelj, B. Sc.
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23. Aleš Svetek, B. Sc.
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Technical officers

25. Stanislav Černe, B. Sc.
26. Giovanni Godena, B. Sc.
27. Dr. Zoran Marinšek***

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28. Janez Grom, *retired 16.08.2007*
29. Maja Janežič, B. Sc.
30. Miroslav Štrubelj

* Full-time faculty member

** Part-time faculty member

*** Member of industrial or other organisation

LABORATORY FOR OPEN SYSTEMS AND NETWORKS

E-5

The main activities of the Laboratory for Open Systems and Networks are the research and development of next-generation networks, telecommunication technologies, components and integrated systems, and information-society services and applications, especially those that ensure an efficient and pervasive life-long learning concept.

In 2007 the research group implemented the research program “Technology, services and business in next-generation networks”. Research was also carried out in the 6FP projects PROLEARN, iCamp and SERENITY, in the MAUSE project from the COST programme, and in a few national projects. The main fields of activity were technology-enhanced learning, security and privacy in information systems, and technologies and services in advanced, next-generation networks.

Technology-enhanced learning

PROLERAN (Network of Excellence in Professional Learning) is a 6FP Network of Excellence in the field of technology-enhanced professional learning. The network brings together the most important research groups in the area of professional learning and training, as well as other key organisations and industrial partners, thus bridging the currently existing gap between research and education at universities and similar organisations and training and continuous education that is provided for and within companies. In 2007 our group was involved in the research of privacy and security in technology-enhanced professional learning, organizational learning and the usability of learning solutions, and in the organization of a summer school for Ph.D. students in Fréjus, France. Research results on usability, privacy and security were published as a chapter in a book, two journal articles and several conference papers. In the research area of organisational learning, we undertook an empirical study that was aimed at connecting the field of information-communication technologies and organizational learning, and evaluating their impact on financial and non-financial business performance. In accordance with stakeholder theory and a balanced scorecard, both the financial and non-financial aspects of the performance were considered. Special attention in the research was given to the presentation of the definitions of the four main constructs of the research model: technology-enhanced learning, organizational learning, financial and non-financial business performance and their operationalisation. The first results have already been published as a chapter in a book and a conference paper.

The project iCamp (Innovative, inclusive, interactive & intercultural learning campus) from the EU 6FP aims at providing an infrastructure – the iCamp Space – for collaboration and social networking across systems, countries and disciplines. The iCamp Space builds on existing interfaces and integrates shared community features. Interoperability amongst different open-source learning systems and tools is the key to the successful sustainability of iCamp. The main goal of the MAUSE (Towards the Maturation of IT Usability Evaluation) project is to bring more science to bear on Usability Evaluation Methods (UEM) development, evaluation, and comparison, aiming for results that can be transferred to industry and educators, thus leading to the increased competitiveness of European industry and benefit to the public.

Security and privacy in information systems

Information security and privacy is one of the most important research fields of the laboratory. Besides the mentioned research on privacy aspects in the field of technology-enhanced learning we addressed security in the integrated project SERENITY (System Engineering for Security & Dependability) from the EU 6FP and in the project VIZIPIN, financed by TIA. In SERENITY we have addressed standardization issues of dynamic security solutions and proposed some potential for standardization. Dynamic security management and control was the core of our work in the VIZIPIN project, where we have adopted the research challenges of the field to potential modern military needs. In 2007 we also started with research on security economics, where we analyse the assessment of the appropriate investment that is economically affordable and provides enough protection for enterprise information systems. The first result, i.e., an approach for the quantification of the necessary investment and a recommendation for a standard approach to security-information investment assessment, has already been accepted for publication in a scientific journal.

In the area of long-term electronic-data protection our research and development updated the protocol LTAP (Long-term Archive Protocol). The protocol was published as an internet draft (draft-ietf-ltans-ltap-05.txt) and is currently being standardized in the IETF LTANS (Long-term Archive and Notary Services) WG.



Head:

Prof. Borka Jerman Blažič

Monitoring and promoting the development of telecommunications

A techno-economic model that provides a tool for designing and applying the appropriate measure for fostering broadband communications and related e-services was finalized in 2007. The main components that influence the development of broadband communications and access services have been identified, and sustainable strategies for fostering its further development analysed. Several papers have been accepted for publication in respective journals.

Some outstanding publications in the past three years

1. Borka Jerman-Blažič, Effie Lai-Chong Law, Tanja Arh. An assessment of the usability of internet based education system in a cross-cultural environment: the case of interreg crossborder program in Central Europe. *Journal of the American Society for Information Science and Technology*. [Print ed.], 2007, vol. 58, no. 1, pp. 66–75.
2. Aleksej Jerman-Blažič, Tomaž Klobučar, Borka Jerman-Blažič. Long-term trusted preservation service using service interaction protocol and evidence records. *Comput. stand. interfaces*. [Print ed.], 2007, vol. 29, no. 3, pp. 398–412.
3. Dušan Gabrijelčič, Borka Jerman-Blažič, Jurij F. Tasič. Future active Ip networks security architecture. *Comput. commun.* [Print ed.], 2005, vol. 28, pp. 688–701.

Organization of conferences, congresses and meetings

1. Multimedia event: “Virtual Global Information Day on the 1st Call on e-Infrastructure (FP7)”, 6. 3. 2007.
2. Organization of PROLEARN summer school, Fréjus, France, from 26. 5. to 2. 6. 2007.
3. Multimedia event: “1st Virtual Forum of Global Research Communities (FP7)”, 12. 7. 2007.

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2. Krešimir Jadronja, Borka Jerman-Blažič
Stimulating broadband deployment and adoption in EU
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6. Effie Lai-Chong Law, Borka Jerman-Blažič, Matija Pipan
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7. Jan Porekar, Kajetan Dolinar, Borka Jerman-Blažič
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8. Tomaž Turk, Borka Jerman-Blažič, Peter Trkman
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In: [in press] 2007.
9. Mitja Tizaj, Tanja Arh
Projektni pristop pri prenovi spletnega portala Cankarjevega doma
In: *Proj. mreža Slov.*, Letn. 10, No. 1, pp. 29-33, 2007.

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Technology-enhanced learning: a strategic advantage for companies' performance - the Slovenian case study
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THESES

M. Sc. Theses

1. Tomaž Breznik: Evaluation of approaches and technologies for privacy protection in Internet (Prof. Borka Jerman Blažič).
2. Robert Zlatanov: Introduction of intercompany electronic business and electronic invoicing in small enterprises. (Prof. Borka Jerman Blažič).
3. Matija Pipan: Methods and techniques for software usability evaluation (Prof. Borka Jerman Blažič).

Specialization Thesis

1. Tanja Marolt: Electronic banking in Slovenia (Prof. Borka Jerman Blažič).

B. Sc. Thesis

1. Tomaž Klančnik: Broadband access networks and their deployment in rural areas (Co-mentor Prof. Borka Jerman Blažič).

INTERNATIONAL PROJECTS

1. Innovative, Inclusive, Interactive & Intercultural Learning Campus
iCAMP, 6. FP, 027168
EC; Claudia Magdalena Fabian, Zentrum für Soziale Innovation, Vienna, Austria
Prof. Borka Jerman Blažič, Dr. Tomaž Klobučar
2. Broadband e-Services and Access for the Home
BReATH, 6. FP, 015893
EC; Rene Kramer, Technische Universiteit Eindhoven, Eindhoven, The Netherlands
Prof. Borka Jerman Blažič
3. Network of Excellence in Professional Learning
PROLEARN, 6. FP, 507310
EC; Martin Wolpers, Universität Hannover, Hannover, Germany
Prof. Borka Jerman Blažič
4. Towards the Maturation of IT Usability Evaluation - MAUSE
COST 294, EC
Prof. Borka Jerman Blažič
5. Innovative Remote Laboratory in the E-training of Mechatronics
MeRLab, Leonardo da Vinci Programme
2007-5050-LdV-TOI
Julija Lapuh Bele, B2, d.o.o., Ljubljana, Slovenia
Matija Pipan, M. Sc.

R & D GRANTS AND CONTRACTS

1. Advanced methods for delivery and administration of location independent personal services
prof. Borka Jerman Blažič
2. Building blocks of educational networks
asst. prof. Tomaž Klobučar
3. Modern didactical concepts, standardisation and knowledge management in e-learning in Slovenian Army
Tanja Arh, M. Sc.
4. Technical and economical models of development of broadband communications and their use in rural areas in Slovenia
prof. Borka Jerman Blažič
5. Knowledge centre for e-learning and convergent multimedia content
Tanja Arh, M. Sc.
6. Developing integral e-learning model of the Slovene national educational system - Min.si
Tanja Arh, M. Sc.

RESEARCH PROGRAM

1. Technologies, services and business in the next generation networks
prof. Borka Jerman Blažič
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VISITORS FROM ABROAD

1. Dr. Klaus-Michael Koch, Technikon, Klagenfurt, Austria, 7. 2. 2007.

STAFF

Researchers

1. Prof. Borka Džonova Jerman-Blažič**, Head
2. Asst. Prof. Tomaž Klobučar

Postdoctoral associates

3. Dr. Dušan Gabrijelčič
4. Dr. Arso Savanovič***

Postgraduates

5. Tanja Arh, M. Sc.
6. Aleksej Jerman Blažič, M. Sc., SETCCE***
7. Andrej Jerman Blažič, B. Sc.
8. Tomaž Klančnik, B. Sc.
9. Matija Pipan, M. Sc.

Technical and administrative staff

10. Tatjana Martun

** Part-time faculty member

*** Member of industrial or other organisation

The Department of Communication Systems is concerned mainly with the research, development and design of next-generation networks, wireless ad-hoc networks and access systems, and the development of new algorithms for parallel and distributed computing and computer simulations. Other research activities include the development of methods and software tools for the modelling, simulation and analysis of communication systems, the provision of security services in communication networks, digital signal processing in medicine, the education of young researchers, and the transfer of knowledge and new technologies to industry.



Head:
Prof. Gorazd Kandus

Research and development activities at the department are carried out in two groups: one specialising in *telecommunication systems* and the other in *parallel and distributed systems*. With the convergence of telecommunications and information systems, the work in both groups is becoming increasingly interconnected, bringing about synergy effects, particularly in applied projects.

Telecommunication Systems

Most of our telecommunication systems' research activities in 2007 were concentrated on terrestrial, stratospheric and satellite access networks. In the access segment these networks present the key for the success of next-generation networks and will enable the end-user to access new services and applications and new multimedia content. We also increased our research activities in the area of wireless ad-hoc and sensor networks. The research emphasis was on the areas of: radio transmission and multiple-input multiple-output (MIMO) systems based on multiple antennas; satellite and stratospheric packet-oriented networks; next-generation networks; and mobile, personal and emergency communications. These research activities were complemented with an investigation of transport network technologies and protocols with special emphasis on route optimisation and mobility management. We continued the work on cross-layer design and the optimisation of communication protocols in wireless communication systems, in order to improve the utilization efficiency of scarce radio resources and to support the provision of quality of service. We were developing advanced and innovative concepts and technologies, enabling interworking, the convergence of networks and the mobility of terminals and networks, with a special emphasis on the solutions providing network robustness, security and quality of services.

In the field of radio communications we studied the radio interface and signal propagation in radio channels, taking into account terrain configuration. The main emphasis was on novel adaptive modulation and coding schemes, synchronization and equalization techniques, and methods to predict the status and assess the quality of radio channels. Particular attention was given to the modulation and coding schemes specified in the IEEE 802.16 and DVB-S2 communication standards. We proposed enhanced decoder-assisted switching between different modulation and coding schemes. We were further investigating low-complexity, efficient, iterative, signal-detection methods and algorithms, applicable to both conventional and advanced multiple-input multiple-output (MIMO) systems. We analysed the implementation complexity of selected procedures in the communication system, the power efficiency of modulation schemes and the capacity of the radio channel. We were investigating new techniques for adaptive space-time coding and multiplexing in MIMO wireless systems that resulted in a successfully defended doctoral dissertation, and looked at a possible extension

We analyzed the modulation and coding schemes specified in the IEEE 802.16 and DVB-S2 communication standards and proposed enhanced decoder-assisted switching between the different modulation and coding schemes.

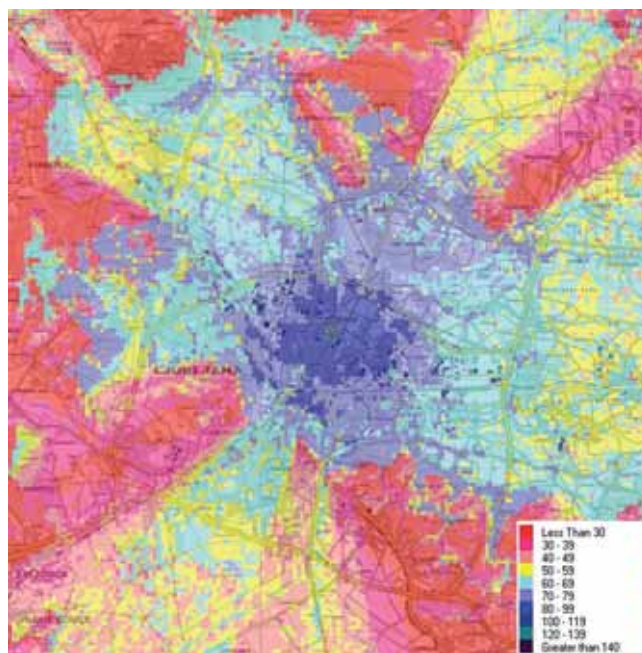


Figure 1: TETRA signal coverage calculation

We contributed to four chapters in the book *Digital satellite communications*, issued in 2007 by Springer, covering Modulation techniques (Ch. 5), Distortion countermeasures (Ch. 7), Diversity techniques and fade mitigation (Ch. 8) and Systems and services (Ch. 11).

of the concept towards virtual and collaborative MIMO systems. We studied the space diversity transmission techniques focusing on the diversity gain in terms of an achievable improvement of the system reliability and availability.

On the network layer we continued our investigations of fixed-mobile convergence and hierarchical mobility. The emphasis in fixed mobile convergence was on mobility management in convergent networks, in particular on the seamless vertical handover between networks based on different access technologies. The measurements of handover execution time showed that the existing mobile packet networks introduce a

significantly larger latency than wireless local area networks. This calls for the development of new, or the adaptation of existing, communication protocols in order to keep the handover latency within certain limits, to avoid any quality-of-service deterioration. For a more detailed performance evaluation and analysis of procedures and protocols for a seamless handover we developed a simulation model of a communication system comprised of WLAN and HSDPA networks using the discrete-event simulation tool OPNET modeler. With this simulation model we verified

the SIP protocol with additional functionality for the handover support and carried out a preliminary analysis. In the frame of hierarchical mobility and routing optimization we were focusing on the modelling of realistic autonomous systems networks, with the emphasis on modelling business relationships, knowledge of which is required for the study of hierarchical mobility. We developed a new algorithm for the improved selection of mobility anchor points based on a future movement prediction capability and analysed its performance in synthetically designed networks, structurally similar to trees, as well as on realistic internet network models with included information on business relationships. In the scope of realistic autonomous system networks, we also studied the deterioration of routing paths from optimality in relation to the topological distance between mobility anchor points and access autonomous systems.

With our research work in the areas of stratospheric and satellite communication systems we also participated in 6FP projects. Within the FP6 project SatNEx (Satellite Communications Network of Excellence) we participated in the design of a network architecture for load balancing and applied it to a multiple HAP constellation. We were investigating the quality-

of-service provision and mobility management in the integrated multiplatform systems consisting of a satellite and a HAP segment. We studied all-optical networking in the HAP network using free space optics and carried out the performance evaluation of HAP-based optical transport networks using different routing and wavelength-assignment algorithms. We also investigated routing procedures in the network of inter-satellite links, focusing on adaptive per-hop routing supporting traffic-class differentiation as well as on the analysis of signalling procedures required for the

implementation of adaptive routing. In this area we published a paper in the international journal *IEEE Transactions on aerospace and electronic systems*, and together with a colleague from ENST Bretagne prepared another paper for publication in the international journal *Space Communications*. In the area of satellite radio communications we studied adaptive modulation and coding procedures, methods for the assessment of the quality of radio channels and methods of spherical decoding, and contributed to four chapters in the book *Digital satellite communications*, issued in 2007 by Springer.

The research work on the 6FP STREP project CAPANINA (Communications from Aerial Platform Networks delivering Broadband Communications for All) was concluded with a report on performance enhancements offered by multiple HAP constellations, investigating in detail the achievable improvement of the system reliability and availability in a mobile operating

environment, and the increased system capacity in a fixed operating environment.

In the scope of the TETRA project for the Ministry of Defence we developed a representative test application comprising telemetry and telecontrol functionalities, making use of the TETRA network as a communication and interconnection platform. In particular, the test application enables monitoring of the temperature at a microcontroller-based remote unit from the control centre and triggering of a remote alarm. A modular approach enables the remote unit to be connected to various types of sensors and appliances, thus satisfying the diverse



Figure 2: TETRA signal strength measurement environment

We developed a test application comprising telemetry and telecontrol functionalities with the TETRA network as a communication and interconnection platform, and validated it using a pilot TETRA MORS network for remote temperature monitoring and public alarm triggering. We also prepared a technical elaborate for the completion of a unified digital radio network for governmental bodies of the Republic of Slovenia.

needs of applications. The designed platform and the representative test application have been validated using the pilot TETRA MORS network. We also prepared a technical elaborate for the completion of a unified digital radio network for governmental bodies of the Republic of Slovenia, and the concept of separated network and user management for the Ministry of Defence. We also developed a simulation model for radio propagation in tunnels and inside buildings, and compared the simulation results with the actual measured signal strength.

Parallel and Distributed Systems

Computer algorithms for efficient and secure implementation on parallel and distributed computers were investigated. Software tools for cluster computing were tested on a 32-processor cluster computer, which runs at our department, and on a grid recently installed in cooperation with the Faculty of Computer and Information Science of the University of Ljubljana and a hi-tech company Xlab d.o.o. A computer simulation for medical applications was investigated and applied to several practical examples. We have developed new numerical methods which, unlike, e.g., the finite-element method, are based on meshless computing. We investigated the computational complexity of mesh-free methods and the possibilities for their parallelization. The work resulted in a publication in a very eminent journal, and there is another paper waiting for publication, which could be of great interest for the wider research community. Team members are also contributing to the book *Parallel Computing: Numerics, Applications, and Trends*, edited by Roman Trobec, Marian Vajtersič and Peter Zinterhof and attracting as contributors many leading authors from the field of parallel computing. The book is to be published at the beginning of 2009 by Springer, in the *Computer Communications and Networks (CCN)* series.

In the field of medical research, the spatial model of a human knee with a resolution of 1 mm was finalized in cooperation with colleagues from the Ljubljana University Clinical Centre (UCC). We improved the simulation of the heat transfer in biological tissues, including heat transfer in the surrounding fluids. In the model we also included heat transfer over capillaries and the metabolic heat source. A parallel simulation program was finalized using advanced numerical methods (multigrid and meshless). Parallel programs for the simulation of human-knee cooling were developed and employed for comparing the results of various post-operative knee-cooling methods, which were selected by the UCC team members. A paper on the subject is already in the review process, and we are preparing another paper, which will report on the results obtained with the improved methods.

It would be unethical to perform measurements on the human heart muscle just to explain a specific phenomenon. With the help of a simulation, however, we were able to investigate the cause of the so-called U-wave, a feature of electrocardiograms (ECG) that has been waiting for an explanation since the beginnings of electrocardiography. We discovered an as yet unknown possibility for the genesis of the wave and reported it in the *Journal of Cardiovascular Electrophysiology*. Together with colleagues from the Ljubljana UCC and the Maribor UCC, we analyzed the heart-beat dynamics of patients before and after a heart operation and obtained promising knowledge for the prediction of post-operative arrhythmias.

In cooperation with medical doctors from the Ljubljana UCC, a mutual interaction among respiration, heart rate and systolic pressure was investigated. The application software for a new measurement system NevroEKG, which is able to acquire, besides ECG, also online signals of respiration rate and blood pressure, was further developed. Based on these encouraging results of the investigations, two doctoral dissertations are being prepared at the UCC. In the area of security in distributed systems, we continued our research on human-factor modelling. The results were published in an eminent international journal.

We improved our simulation software based on mesh-free methods to the extent of facilitating the simulation of moving domains, such as a beating heart. Digitalized spatial models of a human knee and a hand were finalised and prepared for template medical simulations. We simulated the action potentials in an ECG and investigated how the shape, the structure, the motion and the tissue inhomogeneities, present in the adopted heart model, influence the simulated ECG.

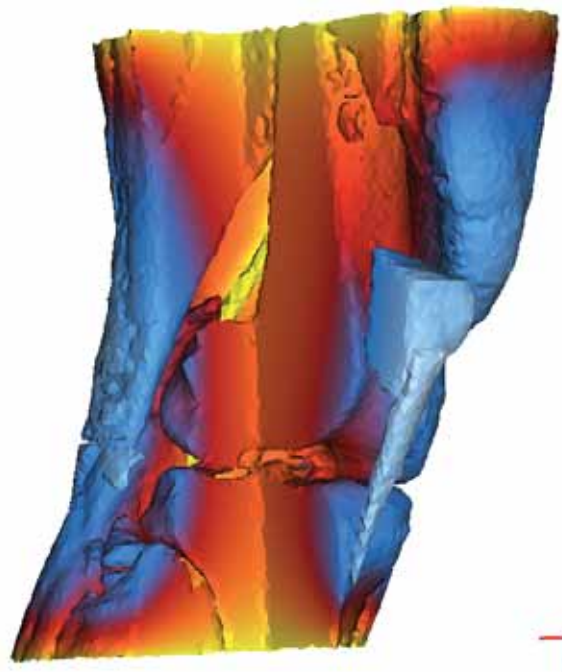


Figure 3: Simulated temperature distribution in a topical cooled knee after hours of cooling. Lower temperatures are in blue color tones; skin and soft tissues are not shown; the artero-lateral quadrant is removed to show the inside the knee.

We developed a new generic method for the synthesis of tests for nondeterministic extended finite-state machines that excels in integrated consideration of all the usual optimization aspects, in supporting a wide class of testing strategies and in facilitating multi-criteria optimization.

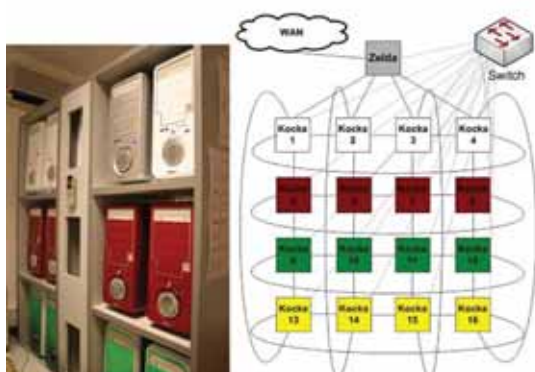


Figure 4: Computing cluster SOKOLI on the department E6: photography (left) and schematic interconnection network (right).

In the field of formal methods for discrete systems modelling and development, we generalized our generic test generation method for deterministic finite-state machines, which supports a wide class of testing strategies, facilitates multi-criteria optimization and always generates a test implementing the given strategy in an optimal manner, to an even wider class of strategies and to nondeterministic extended finite-state machines. We also investigated enhancements of the standard specification language E-LOTOS and developed an operator for specifying the time-dependent reversibility of events, by introducing reversibility, in a very general manner, into enhanced event structures, our formalism developed to facilitate a definition of the true-concurrency semantics of the language. We also improved an algorithm of Gupta, Rahimi and Yang for asynchronous checkpointing and recovery in distributed systems.

Some outstanding publications in 2007

1. M. Kapus-Kolar. Testing as collecting of evidence: an integrated approach to test generation for finite state machines. *Comput. j.*, 2007, vol. 50, no. 3, pp. 315–331.
2. J.-M. Kališnik, V. Avbelj, R. Trobec, B. Geršak. Position-dependent changes in vagal modulation after coronary artery bypass grafting. *Comput. biol. med.*, 2007, vol. 37, no. 10, pp. 1404–1408.
3. A. Švigelj, M. Mohorčič, G. Kandus. Oscillation suppression for traffic class dependent routing in ISL network. *IEEE trans. aerosp. electron. syst.*, 2007, vol. 43, no. 1, pp. 187–196.
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1. Rainer Trummer, Roman Trobec
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Awards and appointments

1. Miha Smolnikar
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4. Matjaž Depolli, Viktor Avbelj, Roman Trobec
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5. Carolina Fortuna, Blaž Fortuna, Mihael Mohorčič
Anomaly detection in computer networks using linear SVMs
In: Zbornik 10. mednarodne multikonference Informacijska družba IS 2007, 8.-12. oktober 2007: zvezek A: volume A (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajković, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenčić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2007, pp. 190-194.
6. Carolina Fortuna, Andrej Hrovat, Mihael Mohorčič, Gorazd Kandus
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7. Andrej Hrovat, Tomaž Javornik, Srečo Plevel, Igor Ozimek, Gorazd Kandus
Primerjava meritev in izračuna pokrivanja z radijskim signalom WiMAX
In: Brežični širokopasovni dostop (VITEL), Devetnajsta delavnica o telekomunikacijah, 16. in 17. april 2007, Brdo pri Kranju, Anton Umek, ed., Tom Erjavec, ed., Anton Kos, ed., Pavel Meše, ed., Boštjan Vlaovič, ed., Ljubljana, Elektrotehniška zveza Slovenije, Slovensko društvo za elektronske komunikacije, cop. 2007, pp. 35-38.
8. Dejan Jurečič, Gorazd Kandus, Tomaž Javornik
Dekodirnik LDPC na osnovi algoritma razširjanja zaupanja
In: Zbornik šestnajste mednarodne Elektrotehniške in računalniške konference ERK

THESES

Ph. D. Thesis

1. Srečo Plevel: Adaptive Multiple Input Multiple Output Wire (prof. Gorazd Kandus)

INTERNATIONAL PROJECTS

1. Support for Participants in ICT Priority by Network for IST under the Transition to the 7th Framework Programme
Idealist7fp, 6. FP, 045059
EC; Dr. Mohsine Chefki, Deutsches Zentrum für Luft- und Raumfahrt E. V. (DLR), Köln, Germany
Asst. Prof. Mihael Mohorčič
2. Satellite Communications Network of Excellence - Phase II
SatNEx- II, 6. FP, 027393
EC; Dörthe Gottschalk, Deutsches Zentrum für Luft- und Raumfahrt E. V. (DLR), Köln;
German Aerospace Center, Weßling, Germany
Prof. Gorazd Kandus
3. Communications from Aerial Platform Networks Delivering Broadband
Communications for All
CAPANINA, 6. FP, 506745
EC; Graham Long, University of York, York Electronics Centre, York, Great Britain
Asst. Prof. Mihael Mohorčič
4. Prevasive Mobile & Ambient Wireless Communications
COST 2100
EC; Prof. Roberto Verdone, DEIS- Università degli Studi di Bologna, Bologna, Italy
Dr. Tomaž Javornik
5. Quality of Service in Future Wireless Systems
COST 290
EC; Prof. Yevgeni Koucheryavy, Tampere University of Technology, Tampere, Finland
Prof. Gorazd Kandus
6. High Altitude Platforms for Communications and other Services
COST 297, HAPCOS
EC; Prof. Tim C. Tozer, University of York, York, Great Britain
Dr. Aleš Švigelj
7. A Telecommunications Economics COST Network - Econ @ Tel
COST IS0605
Prof. Burkhard Stiller, Institut für Informatik - IFI, University of Zürich, Zürich, Switzerland
Prof. Denis Trček
8. Teledoctorate Project
UNESCO-ROSTE Grant
Silvano Pupolin, Università di Padova, Dipartimento di Ingegneria dell'Informazione, Padova;
Dr. Paola Magri, Consorzio Nazionale Interuniversitario per le Telecomunicazioni
(CNIT), Parma, Italy
Prof. Gorazd Kandus

M. Sc. Theses

1. Igor Jelovčan: MIMO detection algorithm for iterative decoding (prof. Gorazd Kandus, prof. Sašo Tomažič)
2. Igor Rozman: Impact of communication on parallel computing in clusters and grids (asst. prof. Roman Trobec)

9. Interactive Visual Analysis of BIO - signals
SEE-ERA.NET, ID 9909
Asst. Prof. Roman Trobec
10. Advanced Technologies for Digital Forensics
Dr. Asmund Skomedal, Norwegian Computing Center, Oslo, Norway
Prof. Denis Trček

R & D GRANTS AND CONTRACTS

1. Lightweight Services for Security, Privacy and Trust Management
Prof. Denis Trček (2008 - Asst. Prof. Roman Novak)
2. Development of advanced digital mobile system TETRA for MOD
Prof. Gorazd Kandus
3. IT development and data gathering, maintenance and management strategy
Asst. Prof. Igor Ozimek
4. Computing GRID technologies for more efficient resources utilization in enterprises
Asst. Prof. Roman Trobec
5. Broadband wireless access networks
Prof. Gorazd Kandus

RESEARCH PROGRAMS

1. Telecommunication systems
Prof. Gorazd Kandus
2. Parallel and distributed systems
Asst. Prof. Roman Trobec

NEW CONTRACTS

1. Security Evaluation of ZZZS Card System Renovation Project
Zavod za zdravstveno zavarovanje Slovenije
Asst. Prof. Roman Novak
2. Information and Communication System for Emergency Medical Services Management and Control
Computel d.o.o.
Prof. Gorazd Kandus

VISITORS FROM ABROAD

1. Dr. Pekka Jäppinen, Lappeenranta University of Technology, Lappeenranta, Finland, 10. 2. - 10. 8. 2007
2. Asst. Prof. Vladimir Crnojević, University of Novi Sad, Novi Sad, Serbia, 3. 4. - 4. 4. 2007
3. Čedomir Stefanović, University of Novi Sad, Novi Sad, Serbia, 3. 4. - 4. 4. 2007

4. Prof. Dragana Bajić, University of Novi Sad, Novi Sad, Serbia, 3. 4. - 4. 4. 2007
5. Marko Trnavac, Faculty of Electronic of Belgrad, Belgrade, Serbia, 2. 7. - 28. 7. 2007
6. Ivan Tomašić M. Sc., Ruder Bošković Institute, Zagreb, Croatia, 28. 11. - 29. 11. 2007
7. Dr. Krešimir Matković, VRVIS - Forschungs, Vienna, Austria, 28. 11. - 29. 11. 2007
8. Yiannis Pavlou, General Manager for National Instruments in Eastern Europe, Budaörs, Hungary, 6. 12. 2007

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1. Dr. Viktor Avbelj
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4. Prof. Monika Kapus Kolar**
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6. Dr. Roman Novak***
7. Asst. Prof. Igor Ozimek***
8. Asst. Prof. Aleš Švigelj**
9. Prof. Denis Trček**, left 01.10.2007
10. Asst. Prof. Roman Trobec**
11. Prof. Matjaž Veselko***

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12. Dr. Marjan Šterk***

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13. Tine Celcer B. Sc.
14. Matjaž Depolli B. Sc.
15. Carolina Fortuna, B. Sc.
16. Andrej Hrovat B. Sc.
17. Igor Jelovčan, B. Sc., left 31. 10. 2007
18. Damjan Kovač M. Sc., left 1. 10. 2007
19. Barbara Maguš, B. Sc.
20. Dr. Srečo Plevel***
21. Igor Rozman B. Sc., left 31. 7. 2007
22. Miha Smolnikar B. Sc.
23. Andrej Vilhar B. Sc.

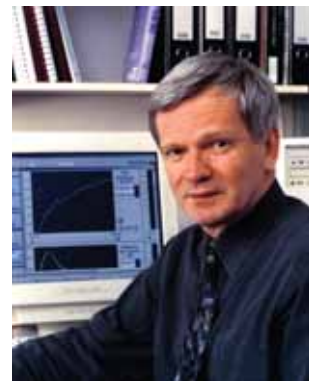
Technical and administrative staff

24. Polona Anžur
25. Barbara Gorjanc
26. Tomaž Kristofelc

** Part-time faculty member

*** Member of industrial or other organisation

The department is concerned primarily with the design automation of computing structures and systems. Within this broad area we are concentrating on metaheuristic approaches to engineering design and logistics problems as well as system design and testing. As an integral part of our research activity, members of the department have close contacts and collaborations with scientists around the world, through academic links and industrial contacts, thus enabling us to keep at the forefront of this rapidly developing field



Head:
Prof. Franc Novak

Metaheuristic optimization algorithms are important for solving hard combinatorial and numerical problems in various domains of theoretical interest and practical applications. We have developed efficient, self-setting and self-adapting evolutionary algorithms and ant-stigmergy-based optimization algorithms. These approaches were used for solving various combinatorial and, more importantly, numerical optimization problems. The evolutionary algorithms were tested on constrained numerical optimization problems. The multiple ant-colonies' approach can be successfully used to solve mesh-partitioning problems that arise in mechanical, civil, automotive, and aerospace engineering. The multilevel ant-stigmergy approach was applied to solving discrete numerical optimization problems. We have proposed a novel, general approach to the transformation of a multi-parameter optimization problem into a problem of finding the cheapest path. We have also developed a differential ant-stigmergy approach that is suitable for solving discrete as well as continuous numerical optimization problems.

The multilevel and differential ant-stigmergy approaches were used on several real-world applications. In collaboration with Domel d.d., Železniki, we reduced the production costs of an electro-motor and optimized the aerodynamic power of a dry vacuum-cleaner impeller. Within the project "The role of Luka Koper in logistic support of the Slovenian Armed Forces and allies" in the frame of the Target research programme (CRP MIR) "Science for Peace and Security 2006-2010" we developed software components for the optimization of logistic procedures for equipment and material transportation. Within the project "Secure infrastructure for implementing command and control" in the frame of the Technology Program (TP MIR) "Technology for Peace and Security 2006-2012" we optimized the structure of an absorber used in telecommunication systems.

In the area of high-performance optimization we also tackled the multi-dimensional knapsack problem, which belongs to the group of NP-complete problems. We designed a new method for solving such a problem in a multi-level way, considering several problems' constraints and objectives that may be conflicting. The method was applied to the problem of composing and balancing multi-day dietary menus. We evaluated the method and compared the results with the nutritional reference values for nutrients and energy to prove its efficiency.

Within the EU 6FP project ARFLEX our work was focused on specific tasks related to the implementation of the visual guidance of an industrial robot, such as sensors-system assessment, sensor selection and adaptation, the development of sensor data-processing software, and the calibration of the sensory system. The work within the sensor-system assessment task included an analysis of vision sensors suitable for robot applications. We identified and compared various types of sensors suitable for industrial robotic applications. As the most promising technology for Arflex, CMOS cameras were selected because of their wide dynamic range, the possibility to choose regions of interest (ROIs) and the high frame rates combined with high resolution. Two of such cameras (PhotonFocus MV-D1024-80) were obtained together with a Camera Link frame grabber (Active Silicon AS-PHX-D48CL-PCI64) and the appropriate optics (Schneider-Kreuznach lens CINEGON 10mm/1.9F with IR filter). Extensive tests of the chosen sensors and equipment were performed in terms of the accuracy of the passive and active marker determinations

The Trimo Research Award was granted to Asst. prof. Peter Korošec for new approaches to the optimization of industrial products proposed in his Ph. D. thesis.



Figure 1: Electrical-motor case: (upper) initial and (bottom) optimized, where its geometrical shape was optimized and the original stiffness kept for a 20% thinner material.

In 2007 the department conducted four projects for the Ministry of Defence together with some other industrial projects. The work on the EU 6FP Arflex is also making good progress

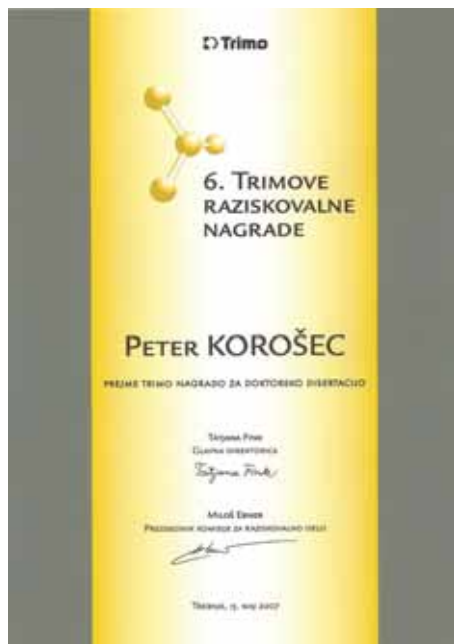


Figure 2: Trimo research award for the industrial applicability of a doctoral thesis.

under dynamic and static conditions in 2D and 3D using the Arflex experimental platform, which was put together in our laboratory. The software modules for the frame grabber and camera interface, the image segmentation and marker extraction, the stereo correspondence, the camera calibration with the robot, the 3D reconstruction and the marker testing were developed in the Windows and Linux environments. The calibration procedure for the vision system with the industrial robot manipulator using a set of nine IR passive markers was investigated and some implementation issues were identified to be solved in future work.

The project “Upgrade of Light Armoured Wheeled Vehicles Valuk 6x6” under the Target research programme (CRP MIR) “Science for Peace and Security 2006-2010” was successfully accomplished with the result of a newly developed hardware interface for the integration of different CBRN detectors in a Valuk military transportation vehicle.

We finalized the development of a secure data-storage unit for casino applications, designed with the emphasis on data security, system availability and system reliability. Special attention was paid to the implementation of a data-cryptography feature. A security extension of the IEEE Std 1149.1 based on a locking mechanism was analyzed for possible attack scenarios.

In the area of electronic testing we have developed an approach for the functional testing of processor cores suitable for a built-in self-test. We generated a test sequence that allows arbitrary situations that might occur in practice and consequently detects faults that only appear in a particular sequence of events. This is accomplished by using a test sequence that explores the functionality of each individual instruction and is composed in such a way that it forms a sensitive path, which can be executed more than once, each time with a different input pattern. Experimental case studies performed on the Xilinx PicoBlaze and MicroBlaze processor cores confirmed the effectiveness of the approach.

In collaboration with the Electronic Ceramics Department and Hyb d. d. we continued our research on the fault diagnosis of piezoresistive ceramic pressure sensors and addressed optimization problems related to yield enhancement in their production.

The industrial project to develop a secure data-storage unit was successfully finalized.

Some outstanding publications in the past three years



Figure 3: Secure data-storage unit for casino systems.

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2. F. Novak, A. Biasizzo, “Security extension for IEEE Std 1149.1”, Journal of Electronic Testing: Theory and Applications, 2006, vol. 22, pp. 301–303.
3. M. Santo Zarnik, D. Belavič, F. Novak, “Finite-element model-based fault diagnosis, a case study of a ceramic pressure sensor structure”, Microelectronics. reliability, 2007, vol. 47, no. 12, pp. 1950–1957.
4. T. Tušar, P. Korošec, G. Papa, B. Filipič, J. Šilc, “A comparative study of stochastic optimization methods in electric motor design”, Applied intelligence, 2007, vol. 27, no. 2, pp. 101–111.
5. K. Oblak, P. Korošec, F. Kosel, J. Šilc, “Multi-parameter numerical optimization of selected thin-walled machine elements using a stigmergic optimization algorithm”, Thin-walled structures, 2007, vol. 45, no. 12, pp. 991–1001.

Awards and appointments

1. Asst. Prof. Peter Korošec: 6th Trimo Research Award for doctoral thesis

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ORIGINAL ARTICLES

- Anton Biasizzo
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- Uroš Kač, Franc Novak
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In: Elektroteh. vestn., Letn. 74, no. 3, pp. 92-98, 2007.
- Uroš Kač, Franc Novak
Oscillation test scheme of SC biquad filters based on internal reconfiguration
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- Barbara Koroušič-Seljak
Dietary menu planning using an evolutionary method
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In: Thin-walled struct., Vol. 45, no. 12, pp. 991-1001, 2007.
- Klemen Oblak, Peter Korošec, Jurij Šilc, Franc Kosel
Stigmergično optimiranje ploskovnih konstrukcij
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- Gregor Papa, Tomasz Garbolino, Franc Novak, Andrzej Hlawiczka
Deterministic test pattern generator design with genetic algorithm approach
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- Marko Pavlin, Franc Novak
Yield enhancement of piezoresistive pressure sensors for automotive applications
In: Sens. actuators, A, Phys., 9 p., [in press] 2007.
- Marina Santo-Zarnik, Darko Belavič, Franc Novak
Finite-element model-based fault diagnosis, a case study of a ceramic pressure sensor structure
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- Jurij Šilc, Theo Ungerer, Borut Robič
Dynamic branch prediction and control speculation
In: International journal of high performance systems architecture, Vol. 1, no. 1, pp. 2-13, 2007.
- Katerina Taškova, Daniela Stojanova, Marko Bohanec, Sašo Džeroski
A qualitative decision-support model for evaluating researchers
In: Informatica (Ljublj.), Vol. 31, no. 4, pp. 479-486, 2007.
- Drago Torkar, Saša Novak, Franc Novak
Apparent viscosity prediction of alumina-paraffin suspensions using artificial neural networks
In: J. mater. process. technol., [in press] 2007.
- Drago Torkar, Gregor Papa
Evaluation of accuracy in a 3D reconstruction system
In: WSEAS trans. comput. control, Vol. 2, no. 2, pp. 149-154, 2007.
- Tea Tušar, Peter Korošec, Gregor Papa, Bogdan Filipič, Jurij Šilc
A comparative study of stochastic optimization methods in electric motor design
In: Appl. intell. (Boston), Vol. 27, no. 2, pp. 101-111, 2007.
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In: Zbornik šestnajste mednarodne Elektrotehniške in računalniške konference ERK 2007, 24. - 26. september 2007, Portorož, Slovenija (Zbornik ... Elektrotehniške in računalniške konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2007, Zv. B, pp. 57-50.
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- Franc Novak, Anton Biasizzo
Implementation of security extension for IEEE Std. 1149.1 and analysis of possible attack scenarios
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- Klemen Oblak, Franc Kosel, Peter Korošec, Jurij Šilc
Večparametrna geometrijska optimizacija kolesa turbopuhala z uporabo stigmergičnega optimizacijskega algoritma
In: Zbornik del, Kuhljevi dnevi 2007, Snovik, 20.-21. september 2007, Jože Korelc, ed., Dejan Zupan, ed., Ljubljana, Slovensko društvo za mehaniko, 2007, pp. [163-170].
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- Daniela Stojanova, Katerina Taškova, Marko Bohanec, Sašo Džeroski
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Robot TCP positioning with vision: accuracy estimation of a robot visual control system
In: ICINCO 2007: proceedings of the Fourth International Conference on Informatics in Control, Automation and Robotics, & workshops Multi Agent Robotic Systems, MARS & Artificial Neural Networks and Intelligent Information Processing, ANNIIP, Angers, France, May 2007, [S. l., s. n.], 2007, pp. 212-215.
- Drago Torkar, Gregor Papa
Accuracy of a 3D reconstruction system
In: Proceedings of the WSEAS International Conferences, Corfu Island, Greece, February 16-19, 2007, 6th WSEAS Int. Conf. on Artificial Intelligence, Knowledge Engineering and Data Bases (AIKED'07) ... [et al.], Charles A. Long, ed., Valeri M. Mladenov, ed., Zoran S. Bojkovic, ed., [S. l.], World Scientific and Engineering Academy and Society, 2007, pp. 146-150.
- Mariusz Wegrzyn, Franc Novak, Anton Biasizzo, Michel Renovell
Functional test of processor cores in FPGA-based applications
In: Proceedings, 43th International Conference on Microelectronics, Devices and Materials and the Workshop on Electronic Testing, September 12. - September 14. 2007, Bled, Slovenia, Janez Trontelj, ed., Iztok Šorli, ed., Ljubljana, MIDEEM - Society for Microelectronics, Electronic Components and Materials, 2007, pp. 177-181.

PUBLISHED CONFERENCE PAPERS

Regular Papers

- Darko Čerepnalkovski, Sašo Džeroski, Katerina Taškova, Ljupčo Todorovski
Learning generic models of dynamic systems
In: Zbornik 10. mednarodne multikonference Informacijska družba IS 2007, 8.-12. oktober 2007: zvezek A: volume A (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2007, pp. 186-189.
- Andrej Florjančič, Marko Pavlin, Jurij Šilc
Procesorji z nizko porabo energije
In: Zbornik šestnajste mednarodne Elektrotehniške in računalniške konference ERK

TEXTBOOKS AND LECTURE NOTES

- Jurij Šilc
Pipelined processors
(Postgraduated courses in new media and e-science), Ljubljana, Jožef Stefan International Postgraduated School, 2007.

PATENT APPLICATION

- Patent application no. P-20070028
Device and approach for transfer of a personal nutrition table and reference values for food integration from computer program into a kitchen scales
Barbara Koroušič-Seljak, Gregor Papa

INTERNATIONAL PROJECTS

1. Adaptive Robots for Flexible Manufacturing Systems
ARFLEX, 6. FP
NMP2-CT-2005-016680
EC; Dr. Gabriella Caporaletti, EICAS Automazione S.p.A., Torino, Italy
Dr. Drago Torkar
2. EC Thematic Network SOKRATES
EIE-Surveyor
225997-CP-1-2005-1-FR-ERASMUS-TNPP
EC; Prof. Jean-Marc Thiriet, Université Joseph Fourier Grenoble, Institut Universitaire de Technologie 1 de Grenoble, Département Réseaux et Télécommunications, Saint Martin d'Hères, France
Prof. Franc Novak
3. New Approaches to SRAM-based FPGA Testing
PROTEUS
BI-FR07-PROTEUS-016
Dr. Michel Renovell, LIRMM, Montpellier, France
Prof. Franc Novak
4. Metaheuristic Mesh Partitioning Algorithms and Parallel FEM Computations on Clusters and Grids
BI-PL/05-07-007
Dr. Roman Wyrzykowski, Częstochowa University of Technology, Częstochowa, Poland
Asst. Prof. Jurij Šilc

R & D GRANTS AND CONTRACTS

1. Upgrade of light armoured wheeled vehicles VALUK 6x6
Dr. Drago Torkar
2. Nutrition for special needs - POVIR
Asst. Prof. Barbara Koroušič Seljak
3. The role of Luka Koper in logistic support of the Slovenian Armed Forces and allies
Asst. Prof. Jurij Šilc

RESEARCH PROGRAM

1. Computing structures and systems
Prof. Franc Novak

NEW CONTRACT

1. Secure infrastructure for implementing command and control
Kolektor Magma d.o.o.
Asst. Prof. Peter Korošec

VISITOR FROM ABROAD

1. dr. Michel Renovell, LIRMM Montpellier, France, 13. September 2007

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1. Dr. Anton Biasizzo
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5. Asst. Prof. Jurij Šilc **

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6. Dr. Uroš Kač***
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9. *Dr. Alenka Žužek*** left 1. 2. 2007*

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13. Mariusz Jerzy Wegrzyn, M. Sc.

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** Part-time faculty member

*** Member of industrial or other organisation

DEPARTMENT OF KNOWLEDGE TECHNOLOGIES

E-8

The Department of Knowledge Technologies performs research in advanced information technologies, aimed at acquiring, storing and managing knowledge to be used in the development of knowledge-based applications. The established areas of knowledge technologies include intelligent data analysis (machine learning, data mining, and knowledge discovery in databases), text and web mining, the semantic web, social network analysis, language technologies and computational linguistics, decision support and knowledge management. The research areas of the department also include web 2.0, the management of virtual organizations, new media and e-science. Besides developing knowledge technologies, we also develop their applications in environmental sciences and ecology, medicine and health care, biomedicine and genetics, and the economy and marketing.



Head:
Prof. Nada Lavrač

In the past year we have continued the development of intelligent data-analysis techniques and methods, particularly methods for subgroup discovery, contrast set mining, utility-based data mining, rule learning and methods for the analysis of structured and multi-relational data with the use of background knowledge in the form of ontologies. We have developed a new algorithm for high-utility frequent itemset mining, which is significantly faster than the existing algorithms. The algorithm for learning Ripple-Down rules was significantly improved in terms of speed and adapted for use in a multilingual text lemmatizer. A subgroup-discovery algorithm was adapted to the problem of contrast-set discovery in two ways: by considering the target class in comparison to all the other classes (one-versus-all) and in comparison to each other class (round-robin). The two approaches were evaluated in a medical application. We have developed a prototype analytical system for minimizing the testing costs of detection and identification of genetically modified crops in food and fodder samples. The most important breakthrough was achieved with a propositional approach to the analysis of structured data, where, in the area of DNA micro-array analysis, we have developed a method for explaining gene expression on the basis of their functions, processes and interactions, enabled by the use of background knowledge in the form of ontologies. Most of this work was done in the scope of the Ph.D. thesis of Igor Trajkovski, which was concluded in the record time of about two years, and resulted in four conference papers and two papers accepted for publication in SCI-indexed journals (IEEE TSMC and Journal of Biomedical Informatics).

In the FP6 STREP project IQ, coordinated by our department, we have developed a number of constraint-based data-mining methods, most notably methods for learning predictive clustering trees and rules (PCTs) for multi-target and structured prediction. The major developments in this area include learning PCTs by beam search, taking into account instance-level clustering constraints while learning PCTs, learning multi-target model trees, learning ensembles of PCTs for multi-target prediction, learning PCTs for clustering short time series, an improved algorithm for learning predictive clustering rules, and an algorithm for multi-target polynomial regression. We have used the developed approaches to analyze data in the areas of medicine (e.g., data on embryonal tumors, within the FP6 STREP project EET Pipeline), bioinformatics (predicting gene functions) and environmental sciences (many different problems, including habitat modelling). We have also developed further approaches to computational scientific discovery, especially the process-based modelling of dynamic systems, and edited a book (published by Springer) that summarizes the state of the art in this area.

Two national projects concerned the development of methods for processing and analysing remote sensing data in the area of forestry, more specifically LIDAR data. We have developed a new algorithm for computing the bare ground relief beneath the forest canopy and consequently for computing vegetation height and canopy models. The LIDAR-based forest information was extrapolated into a wider area by using cheaper Landsat 7 ETM+ satellite data and regression models (predictive clustering trees) learned on a sample area covered by

In 2007 we were involved in 24 EU projects; in one of them we acted as the coordinator. Of these, 10 were successfully concluded this year. We were also active in 29 national and 10 bilateral projects.



Figure 1: Front page of the book *Computational Discovery of Scientific Knowledge*.

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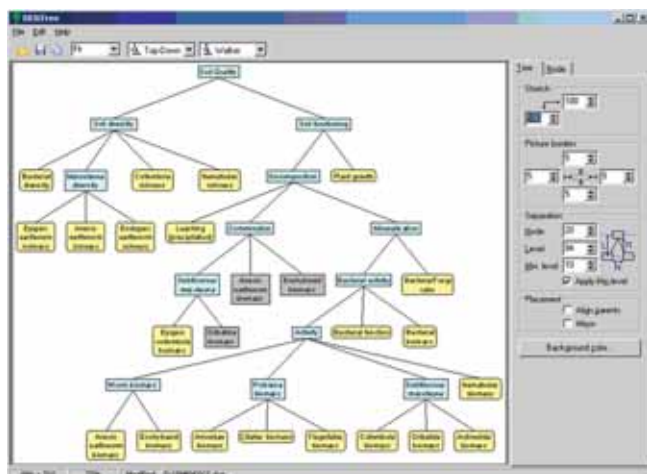


Figure 2: Screenshot of DEXiTree.

Matjaž Juršič received the Prešeren award of Ljubljana University for his bachelor's thesis, conducted under the working mentorship of department members.



Figure 3: The Videolectures portal web page.

both LIDAR and satellite. Two more national projects, as well as the FP6 STREP project SIGMEA, were concerned with the topic of genetically modified organisms, including both crops (maize and oil-seed rape) and trees. Both data-mining approaches and the decision-support approaches were applied to problems in this area (e.g., data mining was used to model gene flow).

In the area of decision support, our long-term goal is to develop methods and techniques for decision modelling, support them with software and integrate them with data-mining systems. In 2007 we have improved our software for qualitative multi-criteria decision making called DEXi. The improvements make possible the construction of general concept hierarchies and thus increase the expressiveness of the models. The data-interchange capabilities and reporting tools of the program were also improved. DEXi 2.0 is freely available from the web page <http://www-ai.ijs.si/MarkoBohanec/dexi.html>. In the new version of DEXi, two supplementary programs were developed, DEXiEval, for the evaluation of alternatives, and DEXiTree, for drawing the structures of multi-criteria models.

The developed methods and tools were successfully used in the EU projects ECOGEN and SIGMEA. The projects are focused on analyses of the ecological and economic impacts of the introduction of genetically modified (GM) plants in European agriculture and on the research of the coexistence of conventional and GM agriculture. ECOGEN was completed with publications in the renowned journal *Pedobiologia*, where we described our models for the evaluation of soil quality and the results of data analyses about the impacts of agronomical practices on communities of soil organisms. In SIGMEA we have developed a software prototype, pSMAC, that evaluates the possibilities for the coexistence of conventional and GM maize production at the level of a single field. pSMAC uses the multi-criteria decision model that was developed in 2006 for the SMAC Advisor decision-support system and extends it with the ability to use probability distributions and more natural methods of the categorization of numerical criteria values. The work in the area of supporting decisions about the introduction of genetically modified crops continues in the EU project Co-Extra.

In the EU project HEALTHREATS, which aims at developing a decision-support system for the rapid, efficient and coordinated response to threats to health (such as epidemics), we are in charge of the development of the models for the internal evaluation of the work and the results of the project. Another two practical applications of multi-criteria modelling should be pointed out: one in the area of electrical and electronic waste disposal (in cooperation with Gorenje) and the other in the area of landscape planning of a seaport (in cooperation with Luka Koper).

In the area of text and web mining we have successfully concluded a bilateral project with Carnegie Mellon University on the Analysis of Dynamic Networks with Graph and Text Mining Methods, where our main contributions are: (1) the development of TimeFall - a new approach to mining temporal graphs - and (2) the efficient implementation of several graph-drawing algorithms, including basic force-directed methods and several state-of-the-art algorithms for drawing huge graphs interactively (FR Fruchterman - Rayngold, linlog vertex and edge repulsion, Harel-Koren - high-dimensional embedding). Our work in the 6FP STREP project SMART (Statistical Multilingual Analysis for Retrieval and Translation) was focused on corpora gathering (European Parliament corpora, Acquis Communautaire corpora, the English-to-Spanish translation of medical texts), the preparation of an automatic evaluation system (of machine translation and cross lingual information retrieval), the definition of user-evaluation scenarios (the definition of user groups, tasks, datasets and evaluation measures, the

relations and requirements of each case study towards the scientific work in the project). As a part of our activities in the 6FP STREP project IMAGINATION (Image-Based Navigation in Multimedia Archives) we have prepared an overview of the state of the art in text mining, with a view to the needs of the project (information extraction and named-entity recognition techniques). Our work in the project was focused on the development of an approach to help enrich the existing textual metadata (available for many images, but usually in limited quantities) based on using the existing metadata to identify relevant Wikipedia articles, the text of which can then be used as an input for additional text-mining processing. Our work in the 6FP SSA project IST-World (Knowledge Base for RTD competencies in IST) resulted in the development of a new method for record linkage using active learning and string kernels. Our research work in the 6FP NoE PASCAL and CA KDUBiq continued in several directions, including the development of efficient methods for calculating a semantic space of several input spaces based on KCCA, the usage of Wikipedia for extracting named entities and relating them over time, the development of SearchPoint, a system for interfacing an existing search engine that organizes its results into groups or shows the search results in the context of some existing ontology or classification schema.

In the area of the Semantic Web we have successfully concluded the 6FP STREP project ALVIS (Superpeer Semantic Search Engine), where our major contributions were (1) the development of a Slovenian lemmatizer based on machine-learning methods, which is an integral part of the ALVIS natural-language processing line of the search engine; and (2) the development of an optimized document-classification web service for classifying into the web directory DMoz, based on machine-learning methods. Our activities in the 6FP IP NeOn (Lifecycle Support for Networked Ontologies) in the past year resulted in several developments: (1) an approach to predicting the structural changes (the addition of a new concept) in an ontology based on machine-learning methods, (2) a pragmatic approach to using large-scale ontologies as contexts (based on a lightweight ontology model and the grounding of the ontology concepts in textual documents) and allowing for the efficient implementation of the basic operations (classification, population and mappings between ontologies), (3) a system for ontology visualization in the context of a predefined landscape. Work in the 6FP STREP project TAO (Transitioning Applications to Ontologies) resulted in: (1) the development of an approach to software mining (extracting knowledge out of the source code and its documentation) based on text mining and link-analysis methods, and (2) the development of the rendering engine and graph-placement algorithms to be used for semantic space-visualization techniques later in the project. In the 6FP STREP project SWING (Semantic Web Services Interoperability for Geospatial Decision Making) we have developed OntoBridge - a system for semi-automatic ontology annotation based on machine-learning techniques. We also represent the Jožef Stefan Institute in the World Wide Web Consortium (W3C), which develops and recommends future web standards. We are also active members of the Rule Interchange Format working group.

In the area of knowledge management we are active in four 6FP research projects. In the ECOLEAD (European collaborative networked organizations leadership initiative) integrated project we are developing a reference model for networked organizations together with the top European authorities in the field. The prototypes that have been developed in the past three years have been tested in a real industrial environment at several European networked organisations that are project partners. In E4 (Extended Enterprise management in Enlarged Europe) we are developing a comprehensive ICT toolset to support collaborative knowledge management. Prototypes like intelligent search, automated classification and annotation, and tools to support ontology management will be installed and tested in 2008 in three industry case studies, such as a multinational distributed manufacturing company, a manufacturing cluster, and a loosely coupled network of SMEs under the chamber of commerce. In Tool-East (Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshops) we have developed a web portal that offers many services to support collaboration between SMEs involved in the tool-

In 2007 we have improved our software for the qualitative multi-criteria decision-making DEXi.



Figure 4: One of the editions of the e-ZISS digital library.

We have developed SearchPoint, a context-sensitive search engine on top of Google (<http://searchpoint.ijs.si/>).



Figure 5: We hosted the international conference Intelligent Data Analysis 2007.

and-die-making industry. The IST-World project is a good example, showing the potential that knowledge technologies have to support knowledge management. The developed portal integrates many prototypes that have been developed in the past in a functional web service, offering automatic data collection and an analysis of European

Tomaž Erjavec chaired the programme committee for ESSLLI 2007, the 19th European Summer School in Logic, Language and Information, which took place at Trinity College, Dublin, 6-17 August 2007.

research. In 2007 we have also been very successful in preparing new project proposals for the 7FP in the area of knowledge management. Three integrated projects have been accepted and will start in 2008: COIN - Collaboration and INteroperability for networked enterprises, EURIDICE - European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics and ACTIVE - Enabling the Knowledge Powered Enterprise.

In the area of language technologies we successfully concluded the project "Scholarly digital critical editions of Slovenian literature" where we, in cooperation with the Institute of Slovenian Literature and Literary Studies at the Scientific Research Center of the Slovenian Academy of Sciences and Arts, produced a digital library of selected Slovene texts, integrating facsimiles, transcriptions and scholarly commentary, in some cases including audiovisual recordings. The technical challenge of the project was in the complexity of the annotations and the linkages of the individual elements of the editions. All the editions are encoded to international standards, in particular the Text Encoding Initiative Guidelines, and freely available under the Creative Commons licence. In 2007 we started work on the basic research project "Linguistic annotation of Slovene language: methods and resources" in the scope of which we are developing automatic inductive methods for the annotation of morphosyntax, syntax and semantics and use these methods to produce freely available linguistically annotated corpora of the Slovene language. In cooperation with the Humanities Faculty of the University of Ljubljana, we are developing a Japanese-Slovene digital dictionary for students of Japanese, we compiled jpWac, a large annotated corpus of Japanese texts gathered from the web. In the scope of the SEE.ERA-NET project "Building Language Resources and Translation Models for Machine Translation focused on South Slavic and Balkan Languages" we started work on a parallel corpus of EU legal documents, which contains aligned texts in English, Slovene, Serbian, Bulgarian and Romanian languages.

Some outstanding publications in 2007

1. Sašo Džeroski (ed.), Ljupčo Todorovski (ed.). Computational discovery of scientific knowledge: introduction, techniques, and applications in environmental and life sciences, (Lecture notes in computer science, Lecture notes in artificial intelligence, 4660), (State-of-the-art survey). Berlin; Heidelberg: Springer, 2007.
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Awards and appointments

1. Nada Lavrač, ECCAI fellow - ECCAI award. Awarded by European Coordination Committee for Artificial Intelligence

Organization of conferences, congresses and meetings

1. Information Society 2007, organization of sub-conferences: SiKDD-2007, Intelligent Systems, 8.-12.10.2007
2. IDA 2007, The 7th International Symposium on Intelligent Data Analysis, Ljubljana, 6.- 8.9.2007

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E4, 6. FP, 027282
EC; Roberto Tarditi, Centro Ricerche Fiat Societa Consortile per Azioni, Orbassano (TO), Italy
Asst. Prof. Dunja Mladenec, Marko Grobelnik, Mitja Jermol, M. Sc.
- Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshop
Tool-East, 6. FP, 027802
EC; Dr.-Ing. Volker Stich, Forschungsinstitut fuer Rationalisierung (FIR) and der RWTH Aachen, Research Institute for Operations Management at Aachen University, Aachen, Germany
Asst. Prof. Dunja Mladenec, Marko Grobelnik, Mitja Jermol, M. Sc.
- Semantic Web Services Interoperability for Geospatial Decision Making
SWING, 6. FP, 026514
EC; Arne J. Berre, SINTEF - Stiftelsen for Industriell OG Teknisk Forskning Ved Norges Tekniske Hoegskole, Trondheim, SINTEF ICT, Oslo, Norway
Asst. Prof. Dunja Mladenec, Marko Grobelnik, Mitja Jermol, M. Sc.
- Lifecycle Support for Networked Ontologies
NEON, 6. FP, 027595
EC; Prof. Enrico Motta, Kmi, The Open University, Milton Keynes, Great Britain
Asst. Prof. Dunja Mladenec, Marko Grobelnik, Mitja Jermol, M. Sc.
- Transitioning Applications to Ontologies
TAO, 6. FP, 026460
EC; Dr. Kalina Bontcheva, University of Sheffield, Department of Computer Science, Sheffield, Great Britain
Asst. Prof. Dunja Mladenec, Marko Grobelnik, Mitja Jermol, M. Sc.
- Inductive Queries for Mining Patterns and Models
IQ, 6. FP, 516169
EC; Prof. Sašo Džeroski, Jožef Stefan Institute, Ljubljana, Slovenia
Prof. Sašo Džeroski
- Knowledge Base for RTD Competencies
IST-WORLD, 6. FP, 015823
EC; Prof. Hans Uszkoreit, German Research Center for Artificial Intelligence GmbH (DFKI), Language Technology Lab, Saarbrücken, Germany
Marko Grobelnik, Mitja Jermol, M. Sc.
- Central European Centre for Women and Youth in Science
CEC-WYS, 6. FP, SAS6-CT-2004-003582
EC; Dr. Marcela Linková, Institute of Sociology, Academy of Sciences of the Czech Republic, Prague, Czech Republic
Asst. Prof. Dunja Mladenec, Mitja Jermol, M. Sc.
- European Collaborative networked Organizations LEADership initiative
ECOLEAD, 6. FP, 506958
EC; Martin Ollus, Technical Research Centre of Finland, Espoo, Finland
Prof. Nada Lavrač, Mitja Jermol, M. Sc.
- Sustainable Introduction of GMOs into European Agriculture
SIGMEA, 6. FP, SSPE-CT-2004-501986
EC; Jeremy Sweet, NIAB, Cambridge, Great Britain
Prof. Sašo Džeroski

16. Superpeer Semantic Search Engine
ALVIS, 6. FP, 002068
EC; Wray Buntine, Complex Systems Computation Group at Helsinki Institute for Information Technology, Helsinki University of Technology, Espoo, Finland
Asst. Prof. Dunja Mladenič, Marko Grobelnik, Mitja Jermol, M. Sc.
17. Pattern Analysis, Statistical Modelling and Computational Learning
PASCAL, 6. FP, 506778
EC; Prof. John Shawe-Taylor, The University of Southampton, School of Electronics and Computer Science, Southampton, Great Britain
Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc.
18. KD-ubiq - A Blueprint for Ubiquitous Knowledge Discovery Systems
KD-ubiq, 6. FP, 021321
EC; Dr. Michael May, Stephan Kollmer, Fabian Perpeet, Fraunhofer Gesellschaft zur Foerderung der Angewandten Forschung e.V., Muenchen; Sankt Augustin, Germany
Asst. Prof. Dunja Mladenič
19. Soil Ecological and Economic Evaluation of Genetically Modified Crops
ECOGEN, 5. FP, QLK5-CT-2002-01666
EC; Dr. Paul Henning Krogh, National Environmental Research Institute, Department of Terrestrial Ecology, Soil Fauna and Ecotoxicology Research Unit, Silkeborg, Denmark
Prof. Sašo Džeroski
20. Integrated Decision Support System for HEALTH THREATS and Crises Management
HEALTHTHREATS, Public Health program (PHEA), 2006203
EC; Executive Agency for Public Health (PHEA - HTC), Luksembourg; Azienda Sanitaria Locale di Brescia (ASL Brescia), Brescia, Italy
Prof. Dr. Nada Lavrač, Dr. Martin Žnidaršič
21. Building Language Resources and Translation Models for Machine Translation focused on South Slavic and Balkan Languages
SEE-ERA.NET
Research Institute for Artificial Intelligence, Bucharest, Romania
Dr. Tomaž Erjavec
22. The Use of a Dedicated Service on the Http Server of IJS <http://nl.ijs.si> to be used by FP for Uploading and Storing Texts which Constitute the FP Corpus of XIX Century Translated Books
Forschungsprojekt: Deutsch-slowenische/kroatische Übersetzung 1848 bis 1918
Agreement dated 3.5.2007
Prof. Erich Prunč, Graz, Austria
Dr. Tomaž Erjavec
23. Knowledge Technologies in Medicine and Healthcare
BI-CZ/06-07-021
Prof. Olga Štěpánková, Czech Technical University in Prague, Faculty of Electrical Engineering Department of Cybernetics, Prague, Czech Republic
Prof. Nada Lavrač
24. Inductive Databases for Genomics and Proteomics
BI-HR/07-08-029
Dr. Tomislav Šmuc, Rudjer Bošković Institute, Zagreb, Croatia
Prof. Sašo Džeroski
25. Intelligent Subgroup Discovery
BI-HR/06-07-021
Dr. Dragan Gamberger, Rudjer Bošković Institute, Zagreb, Croatia
Prof. Nada Lavrač
26. Knowledge Discovery for Ecological Modeling of Lake Ecosystems
BI-MK/07-08-017
Prof. Kosta Mitreski, Faculty of Electrical Engineering, Skopje, The Republic of Macedonia
Prof. Sašo Džeroski
27. Analysis of Dynamic Networks with Graph and Text Mining Methods
BI-US/06-07-032
Faloutsos Christos, Carnegie Mellon University, Pittsburgh, PA, USA
Asst. Prof. Dunja Mladenič

R & D GRANTS AND CONTRACTS

1. Linguistic annotation of Slovene language: methods and resources (Jezikoslovno označevanje slovenskega jezika: metode in viri)
Asst. Prof. Tomaž Erjavec
2. Methodological aspects of cognitive process research-learning and decision-making
Prof. Marko Bohanec
3. Processing lidar data (Development and use of algorithms for mapping and estimating forest biomass and stand structure from LIDAR data and digital multispectral images
Prof. Sašo Džeroski
4. Methodology for producing a detailed digital map of the height and density of vegetation cover
Prof. Sašo Džeroski
5. VoiceTRAN II - Multilingual mobile speech communicator for 21.th century warriors (Večjezični prenosni govorni komunikator za bojevnika 21. stoletja)
Asst. Prof. Tomaž Erjavec
6. SKU - Crisis management simulator
Asst. Prof. Dunja Mladenič
7. Development of Knowledge Management System for SV
Asst. Prof. Dunja Mladenič
8. Statistical semantic web systems
Asst. Prof. Dunja Mladenič
9. Metaservices - Semantic reasoning Grid services
Asst. Prof. Dunja Mladenič
10. Digital text centre with multimedia communication (Elektronsko besedilno središče z multimedijsko komunikacijo)
Asst. Prof. Tomaž Erjavec
11. Harmonisation of technologies for following genetically modified organisms in food and feed production chain and its co-existence with conventional and ecological production chains
Prof. Nada Lavrač
12. Guidelines for national strategy of preservation of forest trees genefond due to introduction of genetically modified organisms in agriculture
Asst. Prof. Marko Debeljak
13. Harmful factors for contemporary forests: methods for monitoring and ecological modelling, the impact of exploitation, and strategies for management
Prof. Sašo Džeroski
14. Slovene Terminology Web Portal
Simon Krek
15. eZISS - Digital Critical Editions of Slovene Literature
Asst. Prof. Tomaž Erjavec

RESEARCH PROGRAM

1. Knowledge Technologies
Prof. Nada Lavrač

NEW CONTRACT

1. Secure infrastructure for implementing command and control
Iskra zaščite d.o.o.
Mitja Jermol, M.Sc.

VISITORS FROM ABROAD

1. Annalisa Appice, Dipartimento di Informatica, Università degli Studi di Bari, Bari, Italy, 31-31.3.2007
2. Prof. Luis Torgo FEP/LIACC, University of Porto, Portugal, 8.-14.1.2007
3. Prof. Tatjana Zrimec, School of Computer Science and Engineering University of New South Wales, Sydney, Australia, 14.-16.1.2007
4. Prof. Claude Sammut, School of Computer Science and Engineering University of New South Wales, Sydney, Australia, 14.-16.1.2007
5. Dr. John Davies, British Telecom, Ipswich, Great Britain, 19.2.2007
6. Ivana Iljašič Mišič, Filozofska fakulteta, Reka, Croatia, 1.3.2007
7. Dr. Božidar Kovačić, Filozofska fakulteta, Reka, Croatia, 1.3.1007
8. Edwin van de Koppel, Univerza v Utrehtu, Utrecht, Netherlands, 1.4.-30.6.2007
9. Prof. Hendrich Blockeel, Katholieke Universiteit Leuven, Belgium, 25.-27.5.2007
10. Prof. Bettina Berendt, Humboldt University Berlin, Institute of Information Systems, Berlin, Germany, 2.4.-17.6.2007
11. Abhijit Bhole, Indian Institute of Technology (IIT) Bombay, India, 7.5. 21.7.2007
12. Dr. Antoine Messean, INRA Eco-INNOV, Grignon, France, 10.-11.7.2007
13. Maja Pivec, University of Applied Sciences - FH Joanneum, Austria, 13.7.2007
14. Dr. Stefano Bertolo, EU Commission, Brussels, Belgium, 6.8.2007
15. Dr. Michael Witbrock, Cypcorp, Inc., Austin, Texas, USA, 20.-27.5.2007 and 6.-26.9.2007
16. Delia Rusu, Technical University of Cluj-Napoca, Romania, Faculty of computer Science, Cluj-Napoca, Romania, 6.8.-29.9.2007
17. Lorand Dali, Technical University of Cluj-Napoca, Romania, Faculty of computer Science, Cluj-Napoca, Romania, 6.8.-29.9.2007
18. Mihaija Chioreanu, Technical University of Cluj-Napoca, Romania, Faculty of computer Science, Cluj-Napoca, Romania, 6.8.-29.9.2007
19. Andreas Krause, Carnegie Mellon University, Pittsburgh, USA, 19.-24.8.2007
20. Jesse Read, University of Waikato, Hamilton, New Zealand, 13.9.-15.12.2007
21. Dr. Karl Oliva, Czech Academy of Science, Prague, Czech Republic, 14.9.2007
22. Jakub Dušek, Academy of Science, Prague, Czech Republic, 14.9.2007
23. Zak Hussain, University of Southampton, Southampton, Great Britain, 2.10.-5.10.2007
24. Dr. Celine Vens, Katholieke Universiteit Leuven, Belgium, 13.10.-16.11.2007.
25. Tomáš Hudík, Faculty of Informatics, Masaryk University, Czech Republic 1.10.2007-29.2.2008
26. Prof. Joost Kok, Leiden University, Leiden, The Netherlands, 14.12.2007
27. Prof. Wray Buntine, University of Helsinki, Finland, 28.11.-2.12.2007
28. Elena Mitreska, Fakulteta za elektrotehniko in informacijske tehnologije, Skopje, Macedonia, 25.11.-2.12.2007
29. doc. dr. Kosta Mitreski, Faculty of Electrical Engineering and Information Technologies, Skopje, Macedonia, 14.-19.5. in 25.11.-2.12.2007
30. Andreja Naumoski, Faculty of Electrical Engineering and Information Technologies, Skopje, Macedonia, 8.-15.12.2007

STAFF

Researchers

1. Prof. Marko Bohanec**
2. Dr. Damjan Bojadžiev
3. Asst. Prof. Bojan Cestnik***
4. Asst. Prof. Marko Debeljak
5. Prof. Sašo Džeroski**
6. Asst. Prof. Tomaž Erjavec**
7. **Prof. Nada Lavrač**, Head**
8. Asst. Prof. Dunja Mladenič**
9. Dr. Igor Mozetič
10. Prof. Tanja Urbančič*

Postdoctoral associates

11. Dr. Damjan Demšar
12. Asst. Prof. Branko Kavšek*
13. *Asst. Prof. Ljupčo Todorovski*, left 31.1.2007*

Postgraduates

14. Janez Brank, M.Sc.
15. Blaž Fortuna, B.Sc.
16. Valentin Gjorgjioski, B. Sc.
17. Miha Grčar, B.Sc.
18. Mitja Jermol, M. Sc.

19. Petra Kralj, B. Sc.
20. Simon Krek**, B. Sc.
21. Pan e Panov, B. Sc.
22. *Joel Plisson, M. Sc., left 1.6.2007*

23. Vid Podpe an, B. Sc.
24. Jan Rupnik, B. Sc.
25. Dr. Miha Volovšek***
26. Miha Vuk, B. Sc.
27. Dr. Bernard Ženko
28. Dr. Martin Žnidarši

Technical officers

29. Dr. France Dacar
30. Nina Novinec, B.Sc.

Technical and administrative staff

31. Tina Anžič
32. Milica Bauer, B.Sc.
33. Marko Grobelnik
34. Jolanda Jakofčič
35. Blaž Novak
36. Boštjan Pajntar

* Full-time faculty member

** Part-time faculty member

*** Member of industrial or other organisation

DEPARTMENT OF INTELLIGENT SYSTEMS

E-9

The Department of Intelligent Systems develops new methods and techniques for intelligent computer systems, with applications in the areas of the information society, computer science and informatics, and network communication systems. The main research areas are language and speech technologies, agent technologies, the semantic web, evolutionary computing, data mining, search algorithms, decision support, intelligent sensors, distributed supervisory systems and network voice services. The department collaborates closely with the Faculty of Computer and Information Science of the University of Ljubljana on the joint research programme Artificial Intelligence and Intelligent Systems, led by Prof. Ivan Bratko.



Head:
Prof. Matjaž Gams

Intelligent systems simulate intelligence so that a typical user seemingly perceives them as truly intelligent. In reality, these systems use complex mechanisms and implement them on digital computers to copy human behaviour as well as possible, and combine them with raw, exponentially growing computer power.

We study **search algorithms** for path-finding and other applications. We explained many cases of the pathological behaviour of these algorithms, i.e., achieving worse results at a greater search depth, and determined in which cases a deeper search is beneficial. It was shown that search algorithms in game trees and single-agent search trees are sensitive to pathology in real-life domains. By analyzing the factors that influence the pathology, it was discovered that pathology can be avoided by using rather simple methods, such as increasing the number of values of the heuristic evaluation function. For path-finding algorithms we are also developing methods for the automatic selection of an optimal search depth and waypoints.

Evolutionary computing is the study of search and optimization techniques that imitate the concepts of Darwinian evolution and genetic variation in the exploration of complex problem spaces. Our research focus was on evolutionary multi-objective optimization, with the algorithm DEMO developed recently at our department. This algorithm is based on single-objective differential evolution, and we showed that on numerical problems it generally outperforms similar multi-objective algorithms that rely on genetic algorithms. Applied studies of evolutionary computation were performed in the process parameter optimization in the continuous casting of steel, marker optimization in textile production, parameter tuning for a PID controller of a laboratory experimental device, and the induction of decision trees to control the process of electrical discharge machining (EDM).

Using **data-mining** techniques, we tackled three different tasks: genre identification, spam filtering and modelling of a tablet-manufacturing process. As part of a doctoral research project in automatic genre classification, we used style-based categorization to identify genres of web pages. Our classifier was tested in a web-search task by specifying genres in combination with keywords. The tests showed a significant improvement in the precision of the retrieved results. We continued our research on sequence classification based on characteristic subsequences of symbols. In addition to previous applications of this method for e-mail filtering, we extended the application domain to include biological sequence analysis. In a preliminary analysis of a pharmaceutical tablet-manufacturing process, we used different classification algorithms to find crucial parameters that influence the quality of the produced tablets.

One of the most promising intelligent approaches is based on **intelligent agents**. Agents have two basic properties: autonomy and sociability. Autonomy denotes the capability of agents to perform actions on their own. The other ability – sociability – makes agents, in principle, potentially stronger than universal Turing machines. Our research includes the learning, modelling and simulation of intelligent agents and multi-agent systems. In 2007, the emphasis was on modelling the strategic multi-agent behaviour

We developed a Multi-Agent Strategy Discovering Algorithm (MASDA), which is able to detect and describe a previously unknown strategy of a team of agents based only on agent trace and low-level domain knowledge. The algorithm was successfully tested on two robot-soccer domains: the RoboCup and the 3vs2 Keepaway.

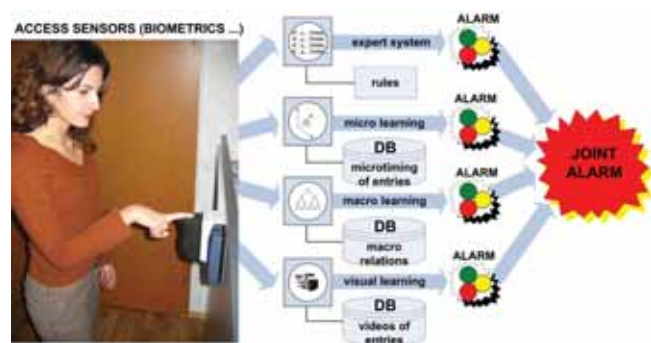


Figure 1: A scheme of the intelligent supervisory system developed by the Department of Intelligent Systems for the Ministry of Defence of the Republic of Slovenia

The Department of Intelligent Systems developed an intelligent event-driven supervisory system for near-real-time and mission-critical operations with a biometric access control and an intelligent expert system (CIVaBiS) for the Slovenian Armed Forces. The project was sponsored by the Ministry of Defence of the Republic of Slovenia.

can be achieved by detecting smaller embedded units. We developed an algorithm for intra-clausal coordination detection, which represents a preprocessing stage of the parsing. Our current topics of research are algorithms for clause detection in sentences.

For the Tax Administration of the Republic of Slovenia the Department of Intelligent Systems provided expert advisory support, analyses, consultations and proposed modifications to the Slovenian taxpayers virtual assistant "Vida". Placed on the Tax Administration website, "Vida" answers common taxpayer questions and provides a good alternative tax-related information source as part of the Slovenian e-government services.

The department developed an intelligent event-driven supervisory system for near-real-time and mission-critical operations with biometric access control and an intelligent expert system (CIVaBiS) for the Slovenian Armed Forces. The project was sponsored by the Ministry of Defence of the Republic of Slovenia, and carried out in collaboration with the industrial partner Spica International and with the Faculty of Electrical Engineering, University of Ljubljana.

Within the **Intelligent Home Telekom (IHT)** project for the national telecom operator Telekom Slovenije we developed the functional and technical design of the intelligent home framework for providing a list of the next-generation intelligent home services with the emphasis on ambient intelligence methods and techniques. The current project will be included in a wider project coordinated by the national telecom operator Telekom Slovenije, with partners such as the Faculty of Electrical Engineering, Goap, d.o.o., and Iskratel, d.d. By the integration of the current

triple-play services (TV, telephony and internet) into key service fields, such as home security, home systems intelligent management and telemedicine, we plan to develop next-generation intelligent-home products and broadband services.

Within the working group for Social Alarms of the Technical Committee for electric alarms of the Slovenian Institute for Standardization (SIST) the department participated in the review of the existing DIND VDE 0834 standard for nurse-call systems and helped to conclude that this standard does not

reflect the state of the art in the medical industry and therefore should not be translated into the Slovenian national standard. Therefore, the JSI supported the proposal to form a new Technical Committee for Social Alarms (local to SIST) to address the development of a new standard for this area.

A traditional activity of the Department of Intelligent Systems is the organization of the International Multiconference "Information Society". In October 2007, the 10th multiconference was held in Ljubljana, consisting of six independent conferences.

We participate in the European project WeGo, aimed at promoting e-government services, and Confidence, which deals with ambient-assisted living. Major applied projects are conducted for the Tax Administration of the Republic of Slovenia, Telekom Slovenije, and the Ministry of Defence of the Republic of Slovenia.

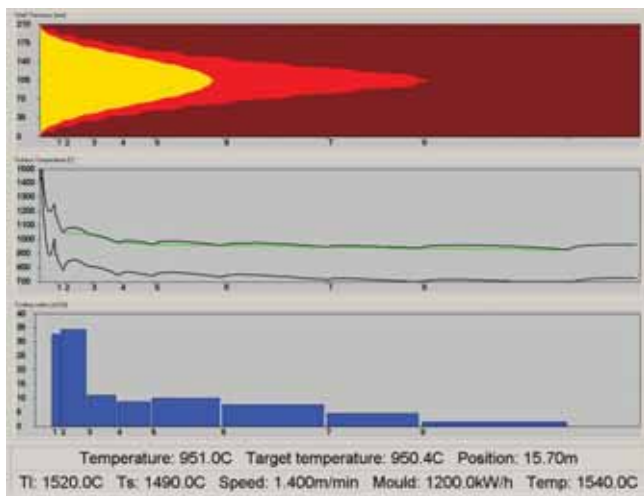


Figure 2: In collaboration with the Department of Mathematical Sciences, University of Oulu, Finland, we are developing a multiobjective optimization methodology for the continuous casting of steel.

Some outstanding publications in the past three years

1. A. Pivk, P. Cimiano, Y. Sure, M. Gams, V. Rajkovič, R. Studer, Transforming arbitrary tables into logical form with TARTAR, *Data & Knowledge Engineering*, 60 (2007), 567–595
2. M. Možina, J. Žabkar, I. Bratko, Argument based machine learning, *Artificial intelligence*, 171 (2007), 922–937
3. A. Bratko, G. V. Cormack, B. Filipič, T. R. Lynam, B. Zupan, Spam filtering using statistical data compression models, *Journal of Machine Learning Research*, 7 (2006), 2673–2698
4. M. Luštrek, M. Gams, I. Bratko, Is real-valued minimax pathological?, *Artificial Intelligence*, 170 (2006), 620–642
5. A. A. Kavalenka, B. Filipič, M. A. Hemminga, J. Štrancar, Speeding up a genetic algorithm for EPR-based spin label characterization of biosystem complexity, *Journal of Chemical Information and Modeling*, 45 (2005), 1628–2635



Figure 3: Academician Prof. Ivan Bratko received an award for his outstanding contribution to the development and promotion of the information society in Slovenia at the 10th International Multiconference Information Society 2007.

Awards and appointments

1. Ivan Bratko: Zois award, Ljubljana, Ministry of Higher Education, Science and Technology, award for top scientific achievements in artificial intelligence

Organization of conferences, congresses and meetings

1. 10th International Multiconference Information Society IS 2007; independent conferences:
 - Cognitive Sciences
 - Collaboration, Software and Services in Information Society
 - Data Mining and Data Warehouses
 - Education in Information Society
 - Intelligent Systems
 - Slovenian Demographic Challenges of the 21st Century
Jožef Stefan Institute, Ljubljana, Slovenia, 8.–12. 10. 2007
2. 8th Workshop “Nature-Inspired Algorithms”, Jožef Stefan Institute, Ljubljana, Slovenia, 28. 05. 2007

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Robert Blatnik, Gorazd Kandus, Tomaž Javornik
VoIP/VoWLAN system performance evaluation with low cost experimental test-bed
In: *WSEAS transactions on communications*, Vol. 6, no. 1, pp. 209-216, 2007.
2. Aleš Dobnikar, Alenka Žužek Nemeč
eGovernment in Slovenia
In: *Informatica (Ljublj.)*, Vol. 31, No. 4, pp. 357-365, Dec. 2007.
3. Bogdan Filipič, Tea Tušar, Erkki Laitinen
Preliminary numerical experiments in multiobjective optimization of a metallurgical production process
In: *Informatica (Ljublj.)*, Vol. 31, no. 2, pp. 233-240, 2007.
4. Iztok Fister, Marjan Mernik, Bogdan Filipič
Optimization of markers in clothing industry: Elektronski vir
In: *Eng. appl. artif. intell.*, [4] f., Available online 22 August 2007.
5. Matjaž Gams, Tea Tušar
Intelligent high-security access control
In: *Informatica (Ljublj.)*, Vol. 31, no. 4, pp. 469-477, 2007.
6. Matej Guid, Ivan Bratko
Computer analysis of chess champions
In: *Computers and games: 5th international conference, CG 2006, Turin, Italy, May 29-31, 2006: revised papers (Lecture notes in computer science, LNCS 4630) (LNCS sublibrary, SL 1, Theoretical computer science and general issues)*, H. Jaap van den Herik, ed., Paolo Ciancarini, ed., H. H. L. M. Jeroen Donkers, ed., Berlin, Heidelberg, New York, Springer, cop. 2007, LNCS 4630, pp. [1]-12, 2007.
7. Matej Guid, Ivan Bratko
Factors affecting diminishing returns for searching deeper
In: *ICGA journal*, Vol. 30, no. 2, pp. 75-84, Jun. 2007.
8. Matej Guid, Ivan Bratko
Računalniška primerjava svetovnih prvakov
In: *Šahov. misel*, Št. 1, pp. 36-44, 2007.
9. Mirjana Kljajić Borštnar, Andrej Škraba, Vladislav Rajkovič, Miroslav Kljajić
Simulation based group learning
In: , pp. 239-247.
10. Tatjana Kozjek, Vladislav Rajkovič, Marko Ferjan
Odločitveni model za izbiro medija pri izvajanju odnosov z javnostmi
In: *Organizacija (Kranj)*, Letn. 40, No. 1, pp. 65-74, jan. 2007.
11. Martin Možina, Jure Žabkar, Ivan Bratko
Argument based machine learning
In: *Artif. intell.*, Vol. 171, no. 10/15, pp. 922-937, 2007.
12. Aleksander Pivk, Philipp Cimiano, York Sure, Matjaž Gams, Vladislav Rajkovič, Rudi Studer
Transforming arbitrary tables into logical form with TARTAR
In: *Data knowl. eng.*, Vol. 60, no. 3, pp. 567-595, 2007.
13. Uroš Rajkovič, Olga Sušteršič, Vladislav Rajkovič, Darja Cibic
The educational challenges of e-representing the international classification of nursing practice
In: *Organizacija (Kranj)*, pp. 258-262.
14. Aleksander Sadikov, Martin Možina, Matej Guid, Jana Krivec, Ivan Bratko
Automated chess tutor
In: *Computers and games: 5th international conference, CG 2006, Turin, Italy, May 29-31, 2006: revised papers (Lecture notes in computer science, LNCS 4630) (LNCS*

- sublibrary, SL 1, Theoretical computer science and general issues), H. Jaap van den Herik, ed., Paolo Ciancarini, ed., H. H. L. M. Jeroen Donkers, ed., Berlin, Heidelberg, New York, Springer, cop. 2007, LNCS 4630, pp. [13]-25, 2007.
15. Aleksander Sadikov, Ivan Bratko
Search versus knowledge revisited again
In: Computers and games: 5th international conference, CG 2006, Turin, Italy, May 29-31, 2006: revised papers (Lecture notes in computer science, LNCS 4630) (LNCS sublibrary, SL 1, Theoretical computer science and general issues), H. Jaap van den Herik, ed., Paolo Ciancarini, ed., H. H. L. M. Jeroen Donkers, ed., Berlin, Heidelberg, New York, Springer, cop. 2007, LNCS 4630, pp. 172-180, 2007.
 16. Alira Srdoč, Ivan Bratko, Alojzij Sluga
Machine learning applied to quality management - a study in ship repair domain
In: Comput. ind., Letn. 58, No. 5, pp. 464-473, 2007.
 17. Tomaž Šef, Primož Baucon
Sodno izvedenstvo in razpoznavanje (identifikacija) govorcev v kazenskem postopku
In: Pravosod. bilt., Letn. 28, 2, pp. 209-228, 2007.
 18. Tea Tušar, Peter Korosec, Gregor Papa, Bogdan Filipič, Jurij Šilc
A comparative study of stochastic optimization methods in electric motor design
In: Appl. intell. (Boston), Vol. 27, no. 2, pp. 101-111, 2007.
 19. Vetrana Vidulin, Mitja Luštrek, Matjaž Gams
Training a genre classifier for automatic classification of web pages
In: CIT. J. Comput. Inf. Technol., Vol. 15, no. 4, pp. 305-311, 2007.
 20. Daniel Vladušič, Boris Kompare, Ivan Bratko
Use of qualitative constraints in modelling of the Lake Glumso
In: Int. j. environ. pollut., Vol. 31, no. 1/2, pp. 107-124, 2007.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Blaž Zupan, Ivan Bratko, Janez Demšar, Peter Juvan, Adam Kuspa, John A. Halter, Gad Shaulsky
Discovery of genetic networks through abduction and qualitative simulation
In: Computational discovery of scientific knowledge: introduction, techniques, and applications in environmental and life sciences (Lecture notes in computer science, Lecture notes in artificial intelligence, 4660) (State-of-the-art-survey), Sašo Džeroski, ed., Ljupčo Todorovski, ed., Berlin, Heidelberg, Springer, 2007, pp. 228-247.
2. Matjaž Gams, Olga Markič, Urban Kordeš
Razvoj kognitivne znanosti v Sloveniji
In: Kognitivna znanost v Ljubljani: možnosti za študij in raziskovalno delo, Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Pedagoška fakulteta, 2007, pp. 23-27.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Matjaž Gams
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INTERNATIONAL PROJECTS

1. Enhancing Western Balkan eGovernment Expertise
We-Go, 6. FP; 045472
EC; Dr. Klaus Josef Gschwendtner, ARC Seibersdorf Research GmbH, Vienna, Austria
Prof. Matjaž Gams
2. Superpeer Semantic Search Engine
ALVIS, 6. FP; 002068
EC; Wray Buntine, Complex Systems Computation Group at Helsinki Institute for Information Technology, Helsinki University of Technology, Espoo, Finland
Prof. Matjaž Gams, Dr. Dunja Mladenich, Marko Grobelnik
3. Securing and Optimising Smart Access and Personal Identification Systems with Intelligent Agents
BI-RO/05-06/016
Dr. Madalin Stefan Vlad, Politehnica University of Bucharest, Bucharest, Romania
Prof. Matjaž Gams

4. AuID: Audio Visual Identification and Detection of Speaker Creability to Give an Assurance of Secure Communication
dr. Tomaž Šef
5. Commanders right hand
prof.dr. Matjaž Gams
6. Knowledge technology and decision support in medical information portals
prof.dr. Matjaž Gams
7. The role of Lika Koper in logistic support of the Sloveniar Armed Forces and allies
dr. Bogdan Filipič

RESEARCH PROGRAM

1. Artificial intelligence and intelligent systems
prof.dr. Matjaž Gams

R & D GRANTS AND CONTRACTS

1. Forensic Speaker Identification
dr. Tomaž Šef
2. Intelligent home researches for Telekom
prof.dr. Matjaž Gams
3. CIVaBIS - An integrated security biometrical system
prof.dr. Matjaž Gams

NEW CONTRACTS

1. Expert counselling for the introduction of tax advisor for Tax Administration of the Republic of Slovenia
Ministry of Finance
Matjaž Gams
2. Implementation PAT for LEK pharmaceutical company
Lek farmacevtska družba d.d.
Matjaž Gams

VISITORS FROM ABROAD

1. Prof. Veljko Milutinović, Faculty of Electrical Engineering, University of Belgrade, Serbia, 02.-04. 04. 2007
2. Prof. Thiemo Krink, Department of Computer Science, University of Aarhus, Denmark, 08.-10. 06. 2007
3. Prof. Veljko Milutinović, Faculty of Electrical Engineering, University of Belgrade, Serbia, 15. 06. 2007
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DEPARTMENT OF REACTOR ENGINEERING

R-4

The Department of Reactor Engineering is involved in basic and applied research in the fields of nuclear engineering and safety. Topics include the modeling of basic thermal-hydrodynamic phenomena, thermal-hydraulic safety analyses of design-basis and severe accidents, structural safety analyses and probabilistic safety assessments. Most of the research activities are part of international cooperation programs. The research results are incorporated into projects for industry and for the regulatory authorities, as well as in graduate studies programmes.

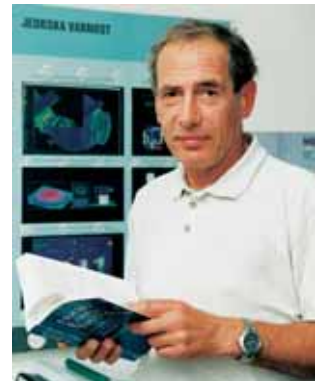
Modelling of basic thermal-hydrodynamic phenomena

In the field of fluid mechanics and heat-transfer research, the computer codes NEPTUNE_CFD, CFX and Fluent were used to analyze inter-phase heat, mass, and momentum transfer in a horizontally stratified flow of cold liquid and hot steam. The emphasis of the work was on the NEPTUNE_CFD code, which is being specially developed for multidimensional simulations of two-phase flow in nuclear engineering. A horizontal pipe filled with hot steam and flooded with a cold liquid, and a horizontal pipe partially filled with a cold liquid with the injection of hot steam, were described. The activities are part of the EU 6FP project NURESIM.

In the field of research on convective boiling, recent experiments from Purdue University (USA) were simulated using a model of nucleate subcooled boiling, which is based on the coupling of a bubble-tracking approach with an Eulerian description. A near-wall model of the turbulent velocity field was also developed for subcooled flow boiling and was implemented into the computer code NEPTUNE-CFD in collaboration with Commissariat à l'Énergie Atomique (France) and EdF (Electricité de France).

In the field of research on pressure transients, various types of water hammer were analyzed with two-way coupling between the thermal-hydrodynamic phenomena in the pipe and the reactions of the flexible piping structure. Unsteady friction models were adopted for the implementation in the computer code WAHA, which was developed within the EU 5FP project WAHALoads to simulate the transients in piping systems.

A steam explosion might occur during a hypothetical severe accident in a nuclear plant if the molten reactor core were to pour into the water in the reactor cavity. A comprehensive ex-vessel steam-explosion study was carried out with the European code MC3D, which we appropriately improved. For a number of relevant scenarios, a molten core discharge from the failed reactor vessel followed by a fuel-coolant interaction was simulated. For each scenario, the steam explosion was triggered and the expected pressure loads on the cavity walls were calculated. The influence of the jet breakup modelling and the droplets freezing on the explosion development and the pressure loads on the cavity walls was analyzed. We also simulated the steam-explosion experiment performed at the TROI facility at the Korea Atomic Energy Research Institute. These activities are being carried out within the SARNET Network of Excellence (EU 6FP) and the OECD project SERENA.



Head:
Prof. Borut Mavko

A near-wall model of the turbulent velocity field was developed for subcooled flow boiling

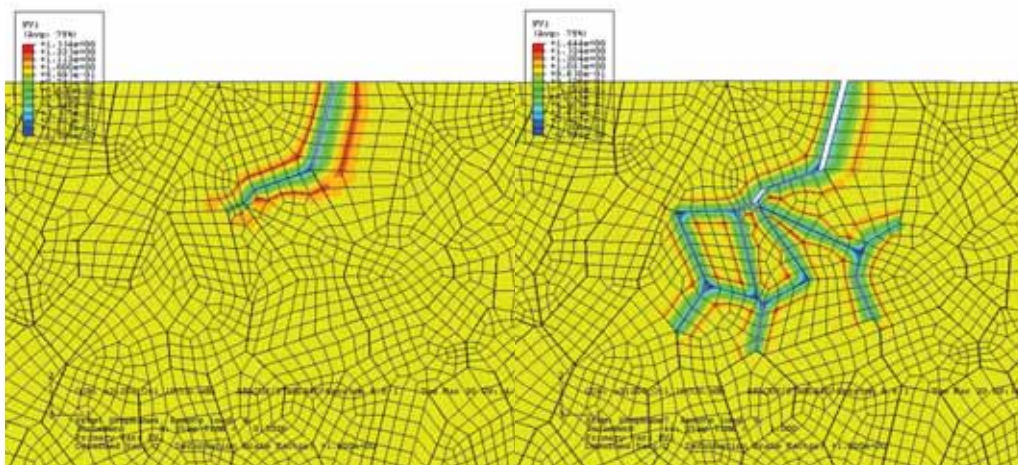


Figure 1: Simulation of an intergranular stress-corrosion crack advance

Multiscale simulations are used to predict the propagation of short cracks in polycrystalline materials.

Thermal-hydraulic safety analyses

Thermal-hydraulic best-estimate computer codes are assessed by comparing code predictions against experimental data from test facilities. The JSI FFTBM Add-In 2007 tool was developed for code-accuracy quantification. The tool, which contains the improved fast-Fourier-transform-based method (FFTBM) and the Stochastic-Approximation-Ratio-based method (SARBM), was used

to verify some conclusions made in the frame of the OECD BEMUSE research project.

Best-estimate calculations for three selected initiating events were performed with the latest RELAP5/MOD3.3 best-estimate thermal-hydraulic code: establishing auxiliary feedwater in the case of a small or medium loss-of-coolant accident, transient in the reactor cooling system, and manual actuation of a safety injection signal. A qualified RELAP5 input model representing a two-loop Westinghouse-type pressurized water reactor was used. The result of this study was an estimation of the operator action success criteria time windows, which is necessary for updating any human reliability analysis.

In the field of modelling of containment phenomena, which is also being carried out within the SARNET network, experiments on containment sprays, performed on the TOSQAN facility at the Institut de Radioprotection et de Sûreté Nucléaire (France), were further simulated with the CFX code. The circulation in the atmosphere of the TOSQAN facility during an experiment on atmosphere mixing was simulated with the lumped-parameter CONTAIN code. The subdivision of the entire volume into control volumes was based on the results of simulations with the CFX code. In cooperation with CEA (France), an experiment on containment atmosphere mixing in the MISTRA facility was simulated with the TONUS-3D code.

Structural safety analyses

A long-term research spotlight is the development of multiscale computational simulation tools for polycrystalline metallic materials. An advanced constitutive model of crystal plasticity is combined with random grain sizes and shapes, represented by Voronoi tessellation. The microscopic stress fields in randomly oriented and shaped grains are then obtained using the finite-element solver ABAQUS. In 2007, we started with additional developments of a crystal plasticity constitutive model with the intention of incorporating the capability of cyclic loads.

The first spatial models of a polycrystalline material were developed in 2007. We successfully quantified the number of grains in the aggregate, above which the influence of grains in the vicinity of a crack-containing grain has a negligible effect. The development of grain-boundary failure models to be used in simulations of intergranular cracking was initiated in cooperation with the Material Performance Centre of Manchester University (United Kingdom). Also, the development of 3D models of aggregates was started in cooperation with CEA (France). These models will enable us to obtain a more complete picture of the influence of the microstructure on short cracks.

A joint program of developing a procedure for obtaining large monocrystals

of austenitic stainless steel was started in 2006 in cooperation with the Institute of Physics (Czech Republic) to provide experimental support for the models.

An industrially supported project aiming at a realistic estimation of the usage of nuclear power plant components started in 2007. The development will be used to support a possible life-time extension of the Krško nuclear power plant.

The list of research partners includes the EU Joint Research Center in Petten (The Netherlands), Forschungszentrum Karlsruhe (Germany) and AIB-Vinçotte Nucléaire (Belgium). We are also members of the European Network of Excellence NULIFE, which is developing the first European virtual research institute devoted to the ageing and safe life-time of nuclear power plant components.

Probabilistic safety assessment

A method for human reliability analysis was developed. The method integrates the results of the deterministic safety analysis, which, based on calculations of the physical parameters, specify the standpoints for determining the success criteria of human actions.

A method for the assessment of power systems' reliability was developed. The fault-tree analysis was integrated with the method for the evaluation of power flows within the system. This integration enables a static fault-tree analysis to be performed with consideration of the specific conditions of the power system, such as power flows and voltage levels.

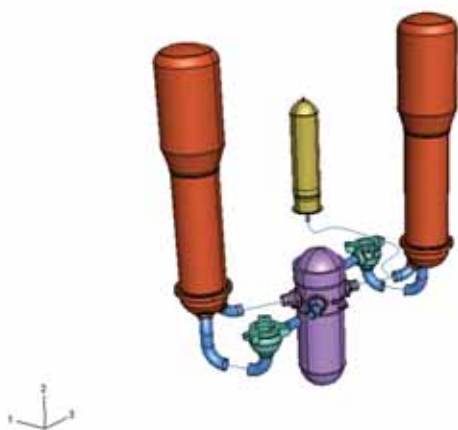


Figure 2: Three-dimensional model of a reactor cooling system for a nuclear power plant

New models for the assessment of ageing within the probabilistic safety assessment were studied. Probabilistic models that are based on a constant failure rate were modified, based on models that may include the time-dependent increase of the failure rate as a consequence of ageing. The problem with new models is the large uncertainty of the results, which is caused by the lack of input data.

Risk criteria were also developed as a support for risk-informed decision-making.

The research is being carried out in cooperation with the Technical University of Ostrava (Czech Republic), the Faculty of Electrical Engineering of Skopje (Macedonia), the Polytechnic University of Valencia (Spain) and the Institute for Energy in Petten (The Netherlands).

Technical cooperation, consulting services and education

In 2007, the Reactor Engineering Department researchers also cooperated in projects for industry and the state administration. As an authorized institution for nuclear safety, the JSI participated in the resolution of Periodic Safety Review Issues in the Krško NPP. The JSI also issues permissions for recriticality and regular operation of the Krško NPP after each regular outage. Members of the department are also actively involved in the Nuclear Engineering Graduate Programme at the Faculty of Mathematics and Physics at the University of Ljubljana. The programme is associated with the European Nuclear Education Network (ENEN) and the European project ENEN-II.

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Awards and appointments

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41. Andrija Volkanovski, Marko Čepin, Borut Mavko
An application of the fault tree analysis for the power system reliability
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Concept of a new method for fatigue monitoring of nuclear power plant components
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- Mirela Gavrilas, Andrej Prošek, (12 avtorjev)
Task group on safety margins action plan, (SMAP): safety margins action plan: final report (Nuclear safety, NEA/CSNI/R(2007)9), Issy-les-Moulineaux, 2007.

TEXTBOOKS AND LECTURE NOTES

- Marko Čepin
PSA - selected methods and applications: seminar Use of PSA in support of NPP maintenance activities
Ljubljana, Jožef Stefan Institute, Reactor Engineering Division, 2007.
- Marko Čepin
PSA applications for maintenance activities - Slovenian perspective: seminar Use of PSA in support of NPP maintenance activities
Ljubljana, Jožef Stefan Institute, Reactor Engineering Division, 2007.
- Marko Kegl, Boštjan Zafošnik, Boštjan Harl
Mehanika I: zbirka nalog za smer Tekstilstvo
Maribor, Fakulteta za strojništvo, 2007.

THESES

Ph. D. Thesis

- Peter Vidmar, Deterministic Model of Fire in Tunnel,
co-mentor: Assoc. Prof. Dr. Iztok Tiselj, May 8, 2007

B. Sc. Thesis

- Maja Požar, Computational Sensitivity Analysis of a Ceramic Armour Plate Impacted by a Projectile, mentor: Assoc. Prof. Dr. Leon Cizelj, April 11, 2007

INTERNATIONAL PROJECTS

- Consolidation of European Nuclear Education, Training and Knowledge Management ENEN-II, 6. FP - EURATOM, 036414
EC; Dr. Peter De Regge, ENEN Association, Centre CEA de Saclay, Gif-sur-Yvette Cedex, France
Prof. Leon Cizelj
- Sustainable Nuclear Fission Technology Platform
SNF-TP, 6. FP, 036410
EC; Prof. Dan G. Cacuci, CEA Saclay, DEN/DIR, Gif-sur-Yvette; Commissariat à l'Énergie Atomique (CEA), Paris, France
Prof. Borut Mavko
- Nuclear Plant Life Prediction
NULIFE, 6. FP, 036412
EC; Valton Teknillinen Tutkimuskeskus (VTT), Espoo, Finland
Prof. Leon Cizelj
- European Platform for Nuclear Reactor Simulations
NURESIM, 6. FP, 516560
EC; Maryline Rougier, CEA Saclay, DEN/DSOE, Gif-Sur-Yvette, France
Prof. Iztok Tiselj
- Network of Excellence for Sustainable Integration of European Research on Severe Accident Phenomenology and Management
SARNET, 6. FP, FI60-CT-2004-509065
EC; Institut de radioprotection et de sureté nucleaire, Clamart, France
Dr. Matjaž Leskovar
- Condensation-Induced Water Hammer in Vertical Vessels
Ref. No.: 05-1000008-8086
INTAS - International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union, Brussels, Belgium;
Prof. Francesco D'Auria, University of PISA, Facoltà di Ingegneria, Dipartimento di

- Ingegneria Nucleare Meccanica e della Produzione (DIMNP), Pisa, Italy
Prof. Iztok Tiselj
7. Steam Explosion Resolution for Nuclear Applications
SERENA, OECD/NEA
Jean Gauvain, OECD Nuclear Energy Agency, Agence de l'OECD pour l'Energie Nucleaire, Issyles-Moulineaux, France
Dr. Matjaž Leskovar
 8. SETH-2 Project to Resolve Key Computational Issues for the Simulation of Thermal-Hydraulic Conditions in Water Reactor Containments
SETH-2, OECD/NEA
Jean Gauvain, OECD Nuclear Energy Agency, Agence de l'OCDE pour l'Énergie Nucléaire, Issyles-Moulineaux, France
Prof. Borut Mavko, Dr. Ivo Klenjak
 9. Code Applications and Maintenance Program (CAMP)
Thermal-Hydraulic Code Applications and Maintenance
International Research Project
Dr. Andrew J. Szukiewicz, Reactor and Plant Systems Branch, Division of Systems Technology, Office of Nuclear Regulatory Research;
Dr. Ashok C. Thadani, Director, Office of Nuclear Regulatory Research, United States Nuclear Regulatory Commission (US NRC), Washington, D. C., USA
Prof. Borut Mavko
 10. Contribution to Best Estimate Plus Uncertainty (BEPU) Analysis Evaluation of Uncertainties in Best Estimate Accident Analysis
13528/R0
IAEA, Vienna, Austria
Dr. Andrej Prošek
 11. The Production of Large Monocrystals of Austenitic Stainless Steel
BI-CZ/06-07-002
Dr. Jaromír Kopeček, Institute of Physics, Academy of Sciences CR, Prague, Czech Republic
Dr. Igor Simonovski
 12. PHEBUS Fission Products Agreement
SLO-F-2003-2008
Daniel Queniat, Acting Director, Institut de Radioprotection et de Surete Nucleaire (IRSN), Clamart, France
Dr. Matjaž Leskovar
 13. Evaluation of Existing and Optimisation of Future Generation in Small Electric Power Systems Considering Economic Analysis and Environmental Impacts
BI-MK/06-07-007
Dr. Anton Čauševski, Department of Power Plants & Power Systems Faculty of Electrical Engineering, Skopje, The Republic of Macedonia
Asst. Prof. Marko Čepin
 6. Multiscale model of Small Crack Initialization and propagation in Pressure Boundary Components of a NPP
Dr. Igor Simonovski
 7. Modeling of Fluid Transport in Nanotubes
Dr. Ivo Kljenak
 8. Simulations of Two-phase Thermalhydraulic Phenomena in Nuclear Engineering by Computational Fluid Dynamics Methods
Dr. Boštjan Končar
 9. Modelling of Explosion Consequences on Equipment and Structures
Dr. Matjaž Leskovar
 10. Application of Methods and Techniques to Assess Ageing and Support Safe Operation of Nuclear Installations and Radiation Facilities
Prof.dr. Leon Cizelj
 11. Improvement of Nuclear Safety with the Probabilistic Safety Assessment
Asst. Prof. Marko Čepin
 12. Conception of a Method for Monitoring of the Usage of NPP Components
Dr. Boštjan Zafošnik
 13. Simulation of thermal-hydraulic phenomena in the atmosphere of a nuclear power plant containment at accident conditions, 2006-2007
Dr. Ivo Kljenak
 14. Influence of corium composition on steam explosion, 2006-2007
Dr. Matjaž Leskovar
 15. Development and validation of turbulent two-phase wall functions for subcooled boiling flow, 2006-2007
Prof.dr. Iztok Tiselj
 16. Simulation of MISTRA Containment Tests with Computational Fluid Dynamics and Lumped-parameter Codes, 2007-2008
Dr. Ivo Kljenak
 17. Use of CFD Approach for Safety Analysis of Nuclear Reactor Systems, 2007-2008
Dr. Boštjan Končar
 18. Prediction of Ex-vessel Steam Explosion Pressure Loads in Reactor Cavity, 2007-2008
Dr. Matjaž Leskovar
 19. The Influence of Microstructural Features on the Short Cracks, 2007-2008
Dr. Igor Simonovski

RESEARCH PROGRAM

1. Nuclear Engineering
Prof.dr. Borut Mavko

NEW CONTRACTS

1. Conception of a Method for Monitoring of the Usage of Nuclear Power Plant Components
Nuclear Power Plant Krško
Dr. Zafošnik Boštjan
2. Improvement and update of Human Reliability in NPPK PSA
Nuclear Power Plant Krško
Asst. Čepin Marko Tomaž
3. Engineering support activities for PSR
Nuclear Power Plant Krško
Prof.dr. Mavko Borut
4. Assessment of Works, Corrective Actions and Tests During Krško NPP Outage
Milan Vidmar electric power research institute, Ljubljana
Fabjan Ljubo, M.Sc.

R & D GRANTS AND CONTRACTS

1. Safety Margins in Nuclear Power Plants
Dr. Andrej Prošek
2. Development of New Safety Models and Definition of Risk Criteria
Asst. Prof. Marko Čepin
3. Simulations of Stratified and Slug Flows
Prof.dr. Iztok Tiselj
4. Modeling of Steam Explosions
Dr. Matjaž Leskovar
5. Modelling of Nonhomogeneous Atmosphere in Nuclear Power Plant Containment
Dr. Ivo Kljenak

VISITORS FROM ABROAD

1. Prof.dr. Anton Čauševski, University of Skopje, Macedonia, 9. -16. 4. 2007
2. Dr. Henri Paillere, CEA, Paris, France, 6.7.2007
3. Duško Kančev, University of Skopje, Macedonia, 9. - 14. 9. 2007

4. Prof. dr. Charles Samuel Martin, Institute of Technology, Atlanta, Georgia, USA, 12. -13. 11. 2007
5. Dr. Jaromír Kopeček, Institute of Physics, AS CR, Prague, Czech Republic, 10. -15. 12.2007

Visiting students from the International Association for the Exchange of Students for Technical Experience (IAESTE):

1. Nicolas Marmin, University of Nantes, Nantes, France, 4. 6. - 31. 8. 2007

STAFF

Researchers

1. Prof. Dr. Leon Cizelj**
2. Asst. Prof. Dr. Marko Tomaž Čepin**
3. Dr. Romana Jordan Cizelj
4. Dr. Ivo Kljenak
5. Dr. Boštjan Končar
6. Dr. Matjaž Leskovar
7. **Prof. Dr. Borut Mavko**, Head**
8. Dr. Andrej Prošek
9. Dr. Igor Simonovski
10. Prof. Dr. Iztok Tiselj**

Postdoctoral associates

11. Dr. Boštjan Zafošnik

Postgraduates

12. Miroslav Babić, B. Sc.
13. Janez Gale, B. Sc.
14. Zoran Petrič, B. Sc.
15. Luka Štrubelj, B. Sc.
16. Mitja Uršič, M. Sc.
17. Andrija Volkanovski, M. Sc.

Technical officers

18. Ljubo Fabjan, M. Sc., 50% IJS QA Manager
19. Andrej Sušnik, B. Sc.

Technical and administrative staff

20. Tanja Klopčič
21. Zlata Vrhovec Mikolič

** Part-time faculty member

REACTOR INFRASTRUCTURE CENTRE

RIC

The TRIGA Mark II Reactor at the Jožef Stefan Institute has been operating since 1966. It is used for neutron research, training and for the production of radioactive isotopes. Besides operating and maintaining the reactor, the members of the reactor staff also cooperate in other activities requiring specialists skilled in working with sources of radiation and in reactor technology, such as the servicing of industrial radioactive sources, and the surveillance of the fuel management in NPP Krško.

A detailed technical description of the reactor is available at <http://www.rcp.ijs.si/~ric/>

In 2007 the reactor operated for 155 days. A total of 1554 samples were irradiated, 1300 of them in the rotary specimen rack, 250 in the pneumatic post system and 4 in the fast pneumatic post system.

The reactor mainly operated in steady-state mode. There were no serious operational problems or events influencing the nuclear or radiological safety. The reactor operators performed regular maintenance inspections and works in accordance with the annual plan.

The hot-cell laboratories became part of the reactor nuclear installation by a decree of the Slovenian Nuclear Safety Administration. Extensive maintenance works were performed in the hot-cell building. The safety report of the hot-cell laboratories was prepared as part of the nuclear safety report of the TRIGA reactor.

The reactor was mainly used for neutron-activation analysis. The reactor operated mainly for the needs of the Jožef Stefan Institute's research departments: the Environmental Science Department, the Reactor Physics Department, the Experimental Particle Physics Department and the Department for Nanostructured Materials. The reactor was used in the following research:

- neutronics and reactor physics,
- activation analysis,
- neutron dosimetry and spectrometry,
- neutron radiography,
- activation of materials, nuclear waste and decommissioning,
- irradiation of materials for fusion reactors.

The reactor operators support the researchers by performing the operations and services for which the researchers are not qualified and authorized, such as operating the reactor, performing irradiations and manipulation with radioactive samples.

The results of this research were published in approximately 20 scientific papers, and three young researchers undertook their research work at the reactor.

Practical exercises for the students of physics at the University of Ljubljana were preformed. The postgraduate students of nuclear engineering attended some of these exercises as well. For these purposes the reactor operated for approximately 10 days. The reactor was also used for practical exercises within the training program of the NPP Krško reactor operators. The exercises were prepared and carried out by the reactor personnel. Approximately 500 visitors visited the reactor.



Head:

Prof. Matjaž Ravnik



Figure 1: New manipulators in the hot-cell laboratory

INTERNATIONAL PROJECT

1. Sale of LEU contained in TRIGA Fuel Elements (10 pcs.) and Natural Yellow Cake (506 kg) AG/3645, HN/PA/06.101 Rev.4

TRIGA International SAS, Courbevoie, France; Hélios Nadal, CERCA, Lyon; Paris La Défence, France; EURATOM SUPPLY AGENCY, Luxembourg

Darko Kavšek, B. Sc., Bogdan Pucelj, M. Sc.

STAFF

Technical officers

1. Bojan Huzjan
2. Darko Kavšek

3. Bojan Oman
 4. **Prof. Matjaž Ravnik, Head**
 5. Marko Rosman
- ### Administrative staff
6. Darja Stich

SCIENCE INFORMATION CENTRE

SIC

The Jožef Stefan Institute's Science Information Centre is the central Slovenian physics library and one of the largest specialist libraries in Slovenia. Our main tasks are the acquisition, archiving, and loan of books and periodicals, and the input, update and control of bibliographic data of the JSI's staff, as requested by the funding ministry.

Our collection covers the fields of physics, chemistry, biochemistry, electronics, information science, artificial intelligence, nuclear technology, energy management and environmental science. We are a full member of the Slovenian library cooperative, COBISS, and use their services to catalogue and loan our materials. You can check what is new in the library, browse our online catalogue, or send inter-library loan requests using our WWW site (<http://library.ijs.si/>).

We supplement our comprehensive collection of core print journals with the electronic editions, offered through our WWW site. We subscribe to the electronic collections offered by ScienceDirect, Springer Link, Stanford HighWire Press, ACS online editions, AIP electronic editions, IoP online journals, Wiley Interscience. We provide access to the SCOPUS, Current Contents, INSPEC, Crossfire Beilstein, and Web of Science databases, and the Dialog online database services.

We manage a bibliographic database of the JSI's production. The database contains about 80,000 records, going back to the JSI's inception in 1949. The records of last year's work are included as part of this report.



Head:
Dr. Luka Šušteršič

STAFF

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1. Jasna Malalan
2. Katarina Modic, B. Sc.
3. Slavka Šmuc, B. Sc.
4. Alenka Štante, B. Sc.
5. Branka Štrancar
6. **Dr. Luka Šušteršič, Head**

7. Marjan Verč, B. Sc.
8. Saša Žnidar

Technical and administrative staff

9. Suzi Korošec
10. Jože Per
11. Nada Tratnik

ENERGY EFFICIENCY CENTRE

EEC

The basic activities of the Energy Efficiency Centre are in efficient energy use, long-term planning in energy and the reduction of greenhouse-gas emissions. The centre is a focal point for the collection and transfer of energy-efficiency technologies to energy users, the state, energy-service and equipment providers, and other interested agencies. At the same time it covers the environmental effects of energy use and conversion. The most significant part of the EEC's activities is thus cooperation with state institutions in the field of efficient energy use, energy planning, environment taxes and emission trading; nevertheless, it still remains strongly connected, by its consulting role in energy, with industrial companies and institutions. The ministry responsible for science, due to the lack of prepared programme documents in the field of research in energy and the environment, supports the above-mentioned activities only symbolically.



Head:
Tomaz Fatur, M. Sc.

Energy and the environment

In 2007 the key activities of the Energy Efficiency Centre were focused on different professional tasks in energy and on the reduction of the impact of energy use on the environment, especially in the field of greenhouse-gas emissions. The EEC has long experience in the fields of energy, energy use, electricity production and, in recent years, on the impact of the production and use of energy on the environment. In connection with this, in 2007 the EEC prepared various strategic studies for the Ministry of the Environment and Spatial Planning and the Ministry of the Economy, necessary for the decisions of both ministries. These studies are from the fields of greenhouse-gas-emissions reduction, the introduction of renewable energy sources (preparation of the Operative Programme for increased wood-biomass exploitation), the preparation of an overview for carrying out of energy policy in Slovenia and similar.

The Energy Efficiency Center played an important role in the elaboration of the strategic basis of the Republic of Slovenia for the preparation of development projects which the government presented to the public. The programme Sustainable Energy and the Economy of Hydrogen was designed right through the research and development work in the Centre, and it plays a key role in the formation of the development priorities of Slovenia. EEC representatives have also actively participated in the preparation of programme documents for obtaining financial resources from European funds, particularly from the cohesion fund and regional development fund.

In 2007 the Energy Efficiency Center cooperated in the preparation of the National Action Plan for Energy Efficiency, accepted by the Slovenian government at the beginning of 2008; this is a key document by which Slovenia will achieve its obligations with regard to energy-use reduction in future years. The centre also cooperated in the preparation of long-term balances of energy development, where new calculations were prepared by the MESAP model for the long-term strategy of energy development in Slovenia up to 2026. The center also carried out support studies and tasks for the field of greenhouse-gas-emissions reduction and other environment views of energy-system operation. In 2006 printed versions were also issued: the Fourth National Communication under the United Nations Framework Convention on Climate Change and Slovenia's report on demonstrable progress under the Kyoto Protocol, which is the cover document of the Slovenian government on the status of greenhouse-gas emissions. Both publications are a result of the research and professional work in the Energy Efficiency Centre and have an important role as a reference document on the situation in Slovenia in the field of greenhouse-gas emissions and the fulfillment of international obligations.

The Energy Efficiency Center cooperated in the preparation of studies on the state and the programmes of waste management in the Municipality of Ljubljana, where current methods of waste management have been presented. The goal of the study is to improve the system of separated waste collection and, in accordance with legislation, prepare such starting points that will enable sustainable waste-management in Slovenia.

The research and development work of the Energy Efficiency Centre staff was an important contribution to the preparation of key documents in Slovenia in the field of energy efficiency (National Action Plan for Energy Efficiency), two EEC representatives cooperated in the group of the Slovenian Government for the Presidency of the European Union Council for the field of climate change.

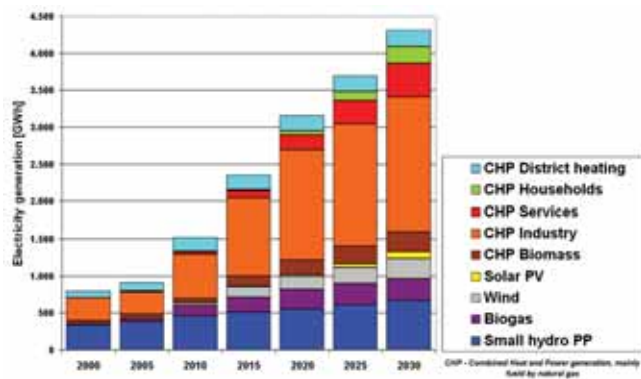


Figure 1: Potential of distributed electricity generation in Slovenia by the year 2030 under intensive technologies deployment promotion.

In the annual review of the Slovenian energy sector for the year 2006 the EEC drew attention to the fact that all energy use and supply indicators show trends which are worse than the expectations of energy politics. This means that political energy mechanisms have not until now have achieved the expected results. In the future, with active EEC participation, it will be necessary to focus on the execution of the mechanisms for energy-use management to improve competitiveness, reliability and the environment.

Promotion of efficient energy use and energy consulting

In this field, the Energy Efficiency Centre was concerned with cooperation in designing, monitoring and evaluating energy-efficiency programmes, the introduction of energy-efficient technologies and energy management, informing and awareness building of energy consumers and other target groups, as well as the promotion of energy-efficient technologies and procedures.

In 2007 the Energy Efficiency Center carried out several consulting tasks for industry and a series of energy audits of enterprises to reduce energy use and costs. Seminars and workshops for industrial companies on energy management, energy-efficient technologies and energy planning were organised. The centre also prepared the programme of the largest Slovenian conference of energy managers, “Energy Managers Days”, the ninth annual meeting of energy managers, and the participation of more than 200 energy managers confirms the quality and public profile of the EEC’s professional work. The centre issues the Energy Efficiency Newsletter for the Agency for the Efficient Use of Energy. Individual EEC experts published numerous articles in magazines and newspapers and took part in radio and television broadcasts.

International Cooperation

In 2007 the EEC carried out as many as 15 international projects, financed from the European Union’s resources in the 6FP and European Commission programme “Intelligent Energy for Europe” (former SAVE and Altener programme).

Projects cover activities in the fields of:

- new technologies and energy efficiency in EU research programmes – Scientific Reference Systems on New Energy Technologies and Energy End-Use Efficiency and Energy RTD (SRS NET & EEE),
- comparison of energy indicators and energy management in medium and small enterprises – Benchmarking and Energy Management Schemes in SMEs,
- compiling and elaborating current data on renewable energy sources use – EurObserv’ER Barometer,
- carrying out 1000 small units for the cogeneration of electricity and heat in Europe – European Campaign for the Development and Documentation of 1000 Small Scale Cogeneration Projects in European Cities and Towns (COGEN CHALLENGE),
- sustainable buildings – GreenBuilding,
- carrying out of the programme MotorChallenge in Slovenia – Dissemination, Extension and Application of the Motor Challenge Programme (DEXA-MCP),
- others.

Projects include cooperation with research and development organisations from Europe, with a strong emphasis on concrete applications and the promotion of energy efficiency. In the framework of each project EEC staff took part in numerous foreign professional meetings and visits. For Intelligent Energy for Europe projects, the EEC acquired partial co-financing from the Ministry for the Environment and Spatial Planning.

Some outstanding achievements in 2007

1. Energy Efficiency Centre (EEC) staff prepared several key support documents for the Government of the Republic of Slovenia. The most important was the National Action Plan for Energy Efficiency for the Period 2008–2016, accepted by the government at the end of January 2008, with which it prepared a plan of fulfillment for the agreement of the European Union member states to achieve 9% of savings of end energy by 2016.
2. In 2007 the Energy Efficiency Centre staff prepared long-term projections of energy development in Slovenia, at the same time they prepared the basis for the negotiations of Slovenia with the European Commission in the field of greenhouse-gas-emissions reduction.
3. The Energy Efficiency Centre has 13 employees, and since 1994 participates in various international projects. In 2007 it cooperated in 15 projects in the framework of the European Commission programmes. These projects are in the fields of energy management, the combined production of electricity and heat, sustainable constructions, external costs in energy, the exploitation of wood biomass and others.

Organization of conferences, congresses and meetings

1. Workshop NEEDS (New Externalities in Decentralised vs. Centralised Energy Services Supply), Ljubljana, March 8, 2007
2. Cogeneration Day, Ljubljana, March 9, 2007
3. Energy Managers Days 2007 – 9th meeting of Slovenian energy managers, Portorož, April 2 – 3, 2007

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Risk analysis for CHP decision making within the conditions of an open electricity market
In: Energy (Oxford), Vol. 32, no. 10, pp. 1905-1916, 2007.
2. Evald Kranjčević
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In: Management of environmental quality, No. 1, Vol. 18, pp. 61-70, 2007.
3. Tomaž Fatur
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In: Finance, Št. 15, 2007.
4. Stane Merše
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5. Stane Merše
500 enot male sproizvodnje
In: Učin. energ., julij, p. 4, 2007.
6. Stane Merše
Mikro sproizvodnja postaja del našega življenja
In: Učin. energ., november, p. 5, 2007.
7. Andreja Urbančič
Energetska politika v EU
In: Učin. energ., Letnik 12, p. 7, 2007.
3. Tomaž Fatur
Energetski menedžment in evropski energetski menedžer
In: [Zbornik predavanj], Dnevi energetikov 2007 [tudi] 9. konferenca energetskih menedžerjev Slovenije, Portorož, 2. in 3. april 2007, Tomaž Fatur, ed., Ljubljana, Časnik Finance, 2007, pp. 1-11, 2007.
4. Tomaž Fatur, Andreja Urbančič
Izzivi na področju učinkovite rabe energije v Sloveniji
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5. Evald Kranjčević, Stane Merše
Small-scale polygeneration market uptake: the Slovenian case
In: Proceedings (Chemical Engineering Transactions, Vol. 12), Proceedings of 10th Conference on Process Integration, Modelling and optimisation for energy Saving and Pollution Reduction, Ischia, June 24-27 2007, Milano, AIDIC, 2007, pp. 629-634.
6. Stane Merše
Spremembe odkupnih cen za sproizvodnjo
In: [Zbornik predavanj], Dnevi energetikov 2007 [tudi] 9. konferenca energetskih menedžerjev Slovenije, Portorož, 2. in 3. april 2007, Tomaž Fatur, ed., Ljubljana, Časnik Finance, 2007, pp. 1-6, 2007.
7. Damir Staničič
Analiza kotlovnice na lesno biomaso
In: [Zbornik predavanj], Dnevi energetikov 2007 [tudi] 9. konferenca energetskih menedžerjev Slovenije, Portorož, 2. in 3. april 2007, Tomaž Fatur, ed., Ljubljana, Časnik Finance, 2007, 17 p., 2007.
8. Andreja Urbančič, Polona Lah, Matjaž Česen, Miha Tomšič, Stane Merše, Andrej Gubina, Iztok Zlatar, Borut Kozan
Strateška izhodišča za pripravo dolgoročnih energetskih bilanc 2005-2030
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9. Andreja Urbančič, Stane Merše, Polona Lah
Perspektiva sproizvodnje toplote in električne energije v Sloveniji
In: Zbornik prispevkov, Konferenca daljinske energetike 2007 Slovenskega društva za daljinsko energetiko = Conference on District Energy 2007, Portorož, 18.-20. marec 2007, Boštjan Bibič, ed., Ljubljana, Slovensko društvo za daljinsko energetiko, 2007, 8 str.

PUBLISHED CONFERENCE PAPERS

Regular Papers

1. Fouad Al-Mansour
Non-technical strategies for overcoming of the barriers and recommendations for further biomass co-firing applications
In: Conference proceedings, 1st Conference of the European Biomass Co-firing Network, July 2-4 2007, Budapest, Budapest, University of West Hungary, 2007, pp. 1-9.
2. Tomaž Fatur
Letni energetski pregled z vidika analize NEP
In: Okolju prijazna uporaba energije kot izziv in nove energetske usmeritve EU, Tomaž Fatur, Celje, Fit media, 2007, pp. 13-24.

INTERNATIONAL PROJECTS

1. Network for Promotion of RT Results in the Field of Eco-building Technologies, Small Polygeneration and Renewable Heating and Cooling Technologies for Buildings ProEcoPolyNet, PEP-Net
6. FP: TREN/05/FP6EN/S07.54455/020114
EC; Michael Geißler, Berliner Energieagentur GmbH (BE), Berlin, Germany
Tomaž Fatur, M. Sc.
2. Scientific Reference System on New Energy Technologies, Energy End-use Efficiency and Energy RTD
SRS NET & EEE
6. FP: 006631
EC; Dr. John Psarras, National Technical University of Athens, Zografou, Greece
Tomaž Fatur, M. Sc.
3. Virtual Balkan Power Centre for Advance of Renewable Energy Sources in Western Balkans VBPC-RES
6. FP: 509205
EC; Dr. Andrej Gubina, University of Ljubljana, Faculty of Electrical Engineering, Ljubljana, Slovenia
Stane Merše, M. Sc.
4. New Energy Externalities Development for Sustainability NEEDS
6. FP: 502687
EC; Adele Vendetti, Istituto di studi per l'Integrazione dei sistemi, Rome, Italy
Dr. Mihael Gabrijel Tomšič
5. Integrated European Network for Biomass Co-firing NETBIOCOF
6. FP - EURATOM; 020007
EC; Maren Watzkat, Verein zur Förderung des Technologietransfers and der Hochschule Bremerhaven E.V., Bremerhaven, Germany
Dr. Fouad Al-Mansour
6. Monitoring of Energy Demand Trends and Energy Efficiency in the EU ODYSSEE MURE (EU-29)
IEE Programme
EIE/07/297/SI2.466291
EC; Didier Bosseboeuf, Agence De l'Environnement et de la Maitrise de l'Energie (ADEME), Angers, France
Dr. Fouad Al-Mansour
7. Training and Network of European EnergyManagers EUREM.NET
IEE Programme
EIE/06/041/SI2.447404
EC; Dr. Robert Schmidt, Tom Ankirchner, dipl.-ing., Industrie-und Handelskammer Nürnberg für Mittelfranken Geschäftsbereich, Innovation/Umwelt, Nürnberg, Germany
Tomaž Fatur, M. Sc.

8. Evaluation and Monitoring of Energy Efficiency in the New EU Member Countries and the EU 25
EEE-NMC
IEE Programme
EIE/05/005/SI2.420008
EC; Didier Bosseboeuf, Agence De l'Environnement et de la Maitrise de l'Energie (ADEME), Angers, France
Dr. Fouad Al-Mansour
9. The European GreenLight Programme in New Member States
NEW GREENLIGHT
IEE Programme
EIE/05/192/SI2.419684
EC; Juraj Krivošik, SEVen, Stredisko pro efektivni vyuzivani energie, o.p.s., The Energy Efficiency Center, Prague, Czech Republic
Evald Kranjčević, M. Sc.
10. Strengthening the Knowledge of Local Management Agencies in the Transport Field
COMPETENCE
IEE Programme
EIE/04/064/S07.38682
EC; Odile Kubarth, Forschungsgesellschaft Mobilität - Austrian Mobility Research - Gemeinnützig GmbH (FGM-AMOR), Graz, Austria
Marko Pečkaj, B. Sc.
11. European Campaign for the Development and Documentation of 1000 Small-scale Cogeneration Projects in European Cities and Towns
COGEN CHALLENGE
IEE Programme
EIE/22003-138, EIE/04/138/S07.38653
EC; Peter Löffler, The European Association for the Promotion of Cogeneration (COGEN), Brussels, Belgium
Stane Merše, M. Sc.
12. Benchmarking and Energy Management Schemes in SMEs
BESS
IEE Programme
EIE/04/246/S07.38678
EC; Roelie Lambrichs-Rozendal, Boudewijn Huenges Wajer, SenterNovem, AA Sittard, The Netherlands
Tomaž Fatur, M. Sc.
13. EurObserv ?ER Barometer
EurObserv ?ER
IEE Programme
EIE/04/014/S07.38552
EC; Diane Lescot, Observ ?ER - Observatoire des Energies Renouvelables, Paris, France
Stane Merše, M. Sc., Polona Lah, B. Sc.
14. Dissemination, Extension and Application of the Motor Challenge Programme
DEXA-MCP
IEE Programme
EIE/04/164/S07.38650
EC; Geraldine Vaidie, Bruno Chretien, Agence de l'environnement et de la maîtrise de l'énergie (ADEME), Angers, France
Tomaž Fatur, M. Sc., Evald Kranjčević, M. Sc.
15. "Bioenergy-Promotion" - Overcoming the Non-technical Barriers of Project Implementation for Bioenergy in Condensed Urban Environments
BioProm
IEE Programme

EIE/04/100/S07.38585
EC; Holger Haas, Stuttgart Region Economic Development Corporation (WRS), Stuttgart, Germany
Tomaž Fatur, M. Sc., Dr. Fouad Al-Mansour

R & D GRANTS AND CONTRACTS

1. Establishment of an EnGIS system for stimulation of renewables and preparation of a multi-sectoral analysis of energy potentials
Tomaž Fatur, M. Sc.

RESEARCH PROGRAM

1. Environment Impact - Modelling and Assessment
Dr. Mihael Gabrijel Tomšič

NEW CONTRACTS

1. Elaboration of Energy and Environment Indicators
Ministry of Environment and Spatial Planning
Matjaž Česen, B. Sc.
2. Expert Advising on Coordination of Positions on Climate Change Issues
Ministry of Environment and Spatial Planning
Andreja Urbančič, M. Sc.
3. Annual Energy Review for 2006
Ministry of Economy
Polona Lah, B. Sc.
4. Elaboration of a National Action Plan for Energy Efficiency
Ministry of Environment and Spatial Planning
Damir Staničič, M. Sc.
5. Elaboration of Strategies for Negotiations about Greenhouse Gases Emissions for RS by 2020
Ministry of Environment and Spatial Planning
Stane Merše, M. Sc.
6. Projections of Greenhouse Gases Emissions to be Reported to EU, Monitoring of GHG Operation Programme and Activities for NEC Directive Revisio
Ministry of Environment and Spatial Planning
Matjaž Česen, B. Sc.
7. Review and Analysis of Development Programmes and Projects of Wastes Treatment
Town Municipality Ljubljana
Tomaž Fatur, M. Sc.
8. Review of Wastes Treatment in the Town Municipality Ljubljana
Town Municipality Ljubljana
Tomaž Fatur, M. Sc.
9. Editing of Energy Efficiency Newsletter
Ministry of Environment and Spatial Planning
Barbara P. Visočnik, M. Sc.

VISITORS FROM ABROAD

1. Silvie Gaggi, ISIS, Milan, Italy, 15.1.2007
2. Andrea Ricci, ISIS, Rome, Italy, 3.8.2007
3. dr. Reinhard Haas, Vienna, Austria, 3.8.2007

4. dr. Wolfram Krewitt, DLR, Stuttgart, Germany, 3.8.2007
5. Fred Starr, JRC, Petten, The Netherlands, 9.3.2007
6. Fiona Riddoch, COGEN Europe, Brussels, Belgium, 9.3.2007
7. Robert Keith Routledge, Ecofys, London, Great Britain, 2.4.2007
8. Ian Behling, AEA Technology, Harwell, Great Britain, 2.4.2007

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Researchers

1. **Tomaž Fatur, M. Sc., Head**
2. Dr. Fouad Al-Mansour
3. Andreja Urbančič, M. Sc.

Technical officers

4. Matjaž Česen, B. Sc.
5. Evald Kranjčević, M. Sc.

6. Stane Merše, M. Sc.
7. Marko Pečkaj, B. Sc.
8. Barbara Petelin Visočnik, M. Sc.
9. Damir Staničič, M. Sc.

Technical and administrative staff

10. Polona Lah, B.Sc.
11. Roza Pergarec, B. A.
12. Igor Ribič
13. Milan Simončič

CENTRE FOR ELECTRON MICROSCOPY

CEM

The Center for Electron Microscopy (CEM) has the function of a supporting infrastructure center that comprises the equipment for electron microscopy that is necessary for the analytical and research work of the departments K5, K6, K7 and K9. Other IJS departments, research institutes, universities and industry also have access to the equipment. The users of the CEM's equipment are the researchers in the field of materials science that are involved in the chemical and structural analyses of materials on the micro and atomic scales. The major pieces of equipment of the CEM are two scanning electron microscopes (JSM-840A and JSM-5800) and two transmission electron microscopes (JEM-2000FX and JEM-2010F).



Head:
Asst. Prof. Miran Čeh

Scanning electron microscopy (SEM) is used for morphological studies of either fractured or polished surfaces. Since both scanning electron microscopes are equipped with X-ray spectroscopy (EDXS, WDXS), qualitative and quantitative chemical analyses on the microscale is also possible. Since only a few μm^3 of the material are nondestructively analyzed, the term electron-probe microanalysis (EPMA) is used for such analytical work.

When structural features on the nanoscale are investigated, however, various techniques of transmission electron microscopy (TEM) are used. In particular, the JEM-2010F is a state-of-the-art TEM/STEM microscope with a FEG (field-emission gun) electron source and is one of the best microscopes in Europe. For the JEM-2010F the point-to-point resolution is below 0.19 nm, which is more than sufficient to observe the atomic columns in crystalline materials. The JEM-2010F is also equipped with an annular dark-field detector (HAADF-STEM) for so-called Z-contrast imaging, which enables the chemical analysis of a single atomic column on the basis of the measured intensities. Both transmission electron microscopes are additionally equipped with analytical systems for chemical analysis (EDS, EELS). The CEM also comprises equipment for SEM and TEM specimen preparation, which is the first step for all electron-microscopy observation procedures. Especially important are the high- and low-energy ion millers, which enable the preparation of thin foils that are transparent to high-energy electrons.

The analytical work that is performed on the CEM's equipment varies, concerning both investigated materials and/or electron-microscopy techniques. While the scanning electron microscopy is used mainly for microstructural characterization and chemical analysis of polycrystalline ceramic materials (functional ceramics, engineering ceramics, bio-ceramics, and composites), magnetic materials, glasses, metals, alloys, etc., the

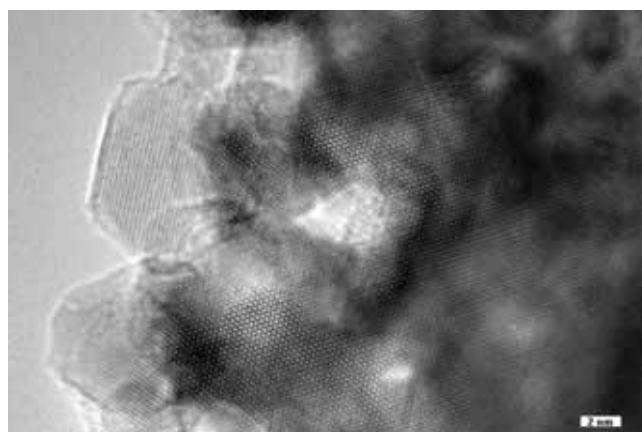


Figure 1: Bioactive hydroxylapatite crystals on the surface of an alumina ceramic substrate. Engineering Ceramics: I. Pribošič.

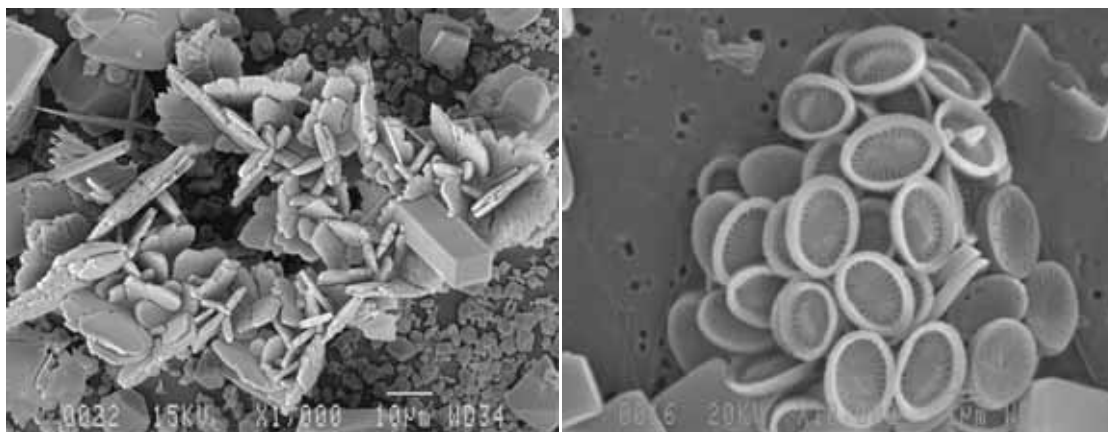
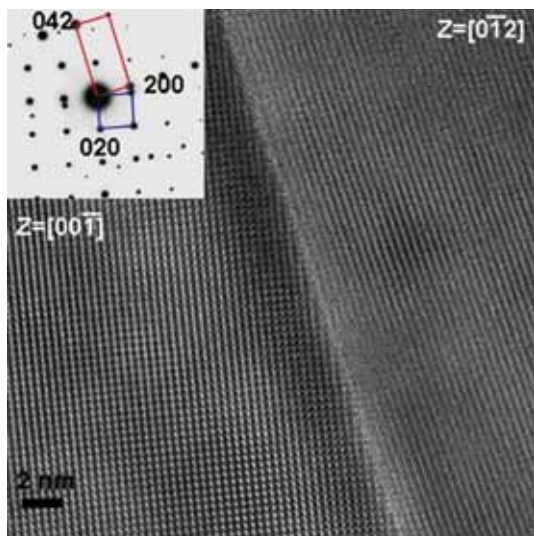


Figure 2: CaCO_3 crystals from drinking water. Nanostructured Materials: Z. Samardžija.

Figure 3: Coccolithophores found in the sediment from Malo and Veliko jezero on the island Mljet. Advanced Materials: S. Škapin.



transmission electron microscopy is used for structural and chemical investigations of grain boundaries, planar faults, dislocations and precipitates within the same materials. The analysis of the grain boundaries is especially important since it is known that the final physical properties to a large extent depend on the structure and chemistry of grain boundaries.

In order to be able to perform electron-microscopy investigations it is imperative that the equipment in the CEM is well maintained. In view of this, one of the main tasks is to attain on maximum possible operational time of the microscopes. This complex and expensive equipment needs regular daily maintenance apart from servicing. Other activities of the CEM are the organization of the training courses for operators and the implementation of new analytical methods, which is realized with the help of CEM co-workers.

Figure 4: High-resolution TEM image of a boundary between two KNN perovskite grains in a ZrO_2 -modified KNN ceramic revealing clean grain boundaries with no segregation of second phases between the grains. The SAED pattern performed on the boundary was indexed with a monoclinic KNN unit cell (PDF: 77-0038). It shows reflections of the KNN grains in the $[00-1]$ and in the $[0-12]$ zone axes. Electronic Ceramics: A. Benčan Golob.

CENTRE FOR KNOWLEDGE TRANSFER IN INFORMATION TECHNOLOGIES CT-3

The Centre for Knowledge Transfer in Information Technologies performs educational, promotional and infrastructural activities and provides the direct exchange of information and experience between researchers and the users of their research results.



Head:
Mitja Jermol, M. Sc.

By partnering and active engagement in various European research projects the centre successfully extends its activities to research and development. Most of the research is performed in the area of knowledge management for traditional and emerging forms of organizations, like networked and virtual organizations. The center is currently active in several European projects: the ECOLEAD Integrated Project (European Collaborative Networked Organisation Leadership Initiative), the PASCAL Network of Excellence (Pattern Analysis, Statistical Modeling and Computational Learning), IST WORLD (Knowledge Base for RTD Competencies), TOOL-EAST (Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshops), E4 (Extended Enterprise Management in Enlarged Europe), NEON (Lifecycle Support for Networked Ontologies), SWING (Semantic Web Services Interoperability for Geospatial Decision Making), IMAGINATION (Image-based Navigation in Multimedia Archives), TAO (Transitioning Applications to Ontologies) and SMART (Statistical Multilingual Analysis for Retrieval and Translation).

We develop and prepare carefully designed educational events, such as seminars, workshops, conferences and summer schools. They are targeted at experts who would like to apply the latest knowledge and achievements from intelligent data analysis, knowledge technologies, data mining, text mining and decision support to the areas of the network organizations, ecology, medicine, business decisions, finance, marketing, automation and process control. A special emphasis is placed on managers and decision makers, who are aware of the strengths and benefits in relation to the success of their business.

All the educational events are designed to transfer basic, additional and the latest expert knowledge to companies, research institutions and educational organizations. In order to make this knowledge transfer efficient we are combining traditional and ICT-supported training methods. For this purpose we are operating a number of training web portals. The most popular one is <http://videlectures.net/>, which is now becoming a reference portal, presenting high-quality scientific lectures. This portal now offers more than 3000 recorded tutorials from different scientific events and is visited daily by an average of 2500 people from around the world.

As part of the IST-World project we have developed a web portal <http://www.ist-world.org> that offers services for automatic data collection and the analysis of European research. The user can perform several simple and complex analyses, predictions and detect trends in research. The database currently contains information about 100,000 research organizations, 42,000 research projects and around 2 million experts from Europe. This is an exceptional web service that is being visited by 5000 unique visitors every day.

In 2007 we organized “The 7th International Symposium on Intelligent Data Analysis” with 100 participants from around the world, the 2nd Student Competition in Computer Science, attended by 80 students from Slovenian secondary schools, and three seminars for 40 participants from industry. We have also organized an international seminar “Transnational ICT and Security Technology Opportunities”. For different EU projects we have organized a total of eight project meetings, four workshops and a summer school.

In addition we have successfully applied for the ECML/PKDD 2009 Conference, which will take place from 7 to 11 September 2009 in Bled.

The centre is operating two web portals. The first one is <http://videlectures.net/>, which is now becoming a reference portal presenting high-quality scientific lectures, and the second one is <http://www.ist-world.org>, which offers services for automatic data collection and an analysis of European research.



Figure 1: IST World portal <http://www.ist-world.org>

In 2007 we have also been very successful in preparing new project proposals for the EU 7FP. Three Integrated Projects, COIN, EURIDICE and ACTIVE, and a Network of Excellence, PASCAL2, have been accepted and will start in 2008.



Figure 2: Videolectures portal <http://videolectures.net/>

In 2007 we have been very successful in preparing new project proposals for the EU 7FP. Three Integrated Projects and a Network of Excellence have been accepted and will start in 2008: COIN - Collaboration and Interoperability for networked enterprises, EURIDICE - European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics, ACTIVE - Enabling the Knowledge Powered Enterprise and PASCAL2 NoE - Pattern Analysis, Statistical Modeling and Computational Learning. Our role in these projects will be the coordination of all the educational and dissemination activities as well as knowledge transfer.

Because of our experience in European projects we are offering consulting services to companies and organizations. In addition we have organized two workshops on the EU 7FP, which were very well attended by participants from industry. The lectures were presented by experienced EU-project proposal writers, project coordinators and partners, project evaluators for the European Commission and a number of young experts with new ideas.

Some outstanding publications in the past three years

1. M. Jermol, N. Lavrač, Virtual learning community: a facilitator of knowledge transfer in collaborative networked organizations. V: Common innovation in e-learning, machine learning and humanoid approaches: Human system learning, who is in control?: proceedings of the Fifth International Conference on Human System Learning (ICHSL.5) = actes du cinquième Colloque International sur l'Apprentissage Personne Système (CAPS.5), (2005), 11-20
2. M. Jermol, B. Jörg, H. Uszkoreit, M. Grobelnik, J. Ferlež, A. Kiryakov, Analytical information services for the European research area. V: Cunningham, Paul (ur.), Cunningham, Miriam (ur.). Exploiting the knowledge economy: issues, applications and case studies, (Information and communication technologies and the knowledge economy, Vol. 3). Amsterdam [etc.]: IOS Press, (2006), 1367-1395
3. M. Jermol, M. Jurančič, Von der leichtigkeit Last des Neustarts : Forschungskoooperation nach dem Kommunismus: Slowenien. V: Gögl, Hans-joachim (ur.), Schleder, Clemens Theobert (ur.). Wissen schafft Unternehmen: erfolgreiche Kooperationsmodelle zwischen Universitäten und Unternehmen in Europa, (Landschaft des wissens, band 2). Bern; Stuttgart; Wien: Haupt, (2006), 330-367

Organization of conferences, congresses and meetings

1. Meeting of the EU project NeOn (Lifecycle Support for Networked Ontologies), Bled, 23.-26.1.2007
2. Seminar »Proizvodni management in informatika«, Ljubljana, 29.1.-2.2.2007
3. Workshop »Women in ICT«, Ljubljana, 16.2.2007
4. Seminar »7. Okvirni program (FP7) - Preparation for the first FP7 calls in the year 2007«, Ljubljana, 20.2.2007
5. Seminar »7. Okvirni program (FP7) - Priprava na prve razpise FP7 v letu 2007«, Ljubljana, 22.2.2007
6. Seminar »Projekti avtomatizacija in informatizacije«, Ljubljana, 26.-30.3.2007
7. 2nd Student Competition in Computer Science, Ljubljana, 31.3.2007
8. Meeting of the EU project IMAGINATION (Image-based Navigation in Multimedia Archives), Bled, 16.-17.4.2007
9. Workshop »Transnational ICT and Security Technology Opportunities«, Ljubljana, 31.5.2007
10. Meeting of the EU project NeOn (Lifecycle Support for Networked Ontologies), Dubrovnik, 27.-29.6.2007
11. "The 7th International Symposium on Intelligent Data Analysis", Ljubljana, 6.-8.9.2007
12. "2nd ECOLEAD Summer School on Virtual Enterprises, Collaborative Networks and Artificial Intelligence Tools for Support of their Activities", Prague, 6-8.9.2007
13. Meeting of the EU project ta SMART (Statistical Multilingual Analysis for Retrieval and Translation), Bled, 1.-2.10.2007
14. Seminar »Gradniki sistemov računalniške avtomatizacije«, Ljubljana, 22.-26.10.2007
15. "Networked organizations - EU projects results and lessons learnt", Bled, 29.-30.11.2007

INTERNATIONAL PROJECTS

1. Stimulating Policy Debate on Women and Science Issues in Central Europe
WS DEBATE, 6. FP, 036651
EC; Dr. Dora Groo, Eszter Papp, Hungarian Science and Technology Foundation; Tudományes Technológiai Alapítvány, Budapest, Hungary
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
2. Statistical Multilingual Analysis for Retrieval and Translation
SMART, 6. FP, 035917
EC; Nicola Cancedda, Xerox Research Centre Europe, Meylan; Xerox, Aulnay-Sous-Bois, France
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
3. Image-based Navigation in Multimedia Archives
IMAGINATION, 6. FP, 034626
EC; Clemens van Dinther, Forschungszentrum Informatik an der Universitaet Karlsruhe, Karlsruhe, Germany
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič
4. Extended Enterprise Management in Enlarged Europe
E4, 6. FP, 027282
EC; Roberto Tarditi, Centro Ricerche Fiat Societa Consortile per Azioni, Orbassano (TO), Italy
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
5. Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshop
Tool-East, 6. FP, 027802
EC; Dr.-Ing. Volker Stich, Forschungsinstitut fuer Rationalisierung (FIR) und der RWTH Aachen, Research Institute for Operations Management at Aachen University, Aachen, Germany
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
6. Semantic Web Services Interoperability for Geospatial Decision Making
SWING, 6. FP, 026514
EC; Arne J. Berre, SINTEF - Stiftelsen for Industriell OG Teknisk Forskning Ved Norges Tekniske Hoegskole, Trondheim; SINTEF ICT, Oslo, Norway
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
7. Lifecycle Support for Networked Ontologies
NEON, 6. FP, 027595
EC; Prof. Enrico Motta, KMI, The Open University, Milton Keynes, Great Britain
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
8. Transitioning Applications to Ontologies
TAO, 6. FP, 026460
EC; Dr. Kalina Bontcheva, University of Sheffield, Department of Computer Science, Sheffield, Great Britain
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
9. Knowledge Base for RTD Competencies
IST-WORLD, 6. FP, 015823
EC; Prof. Hans Uszkoreit, German Research Center for Artificial Intelligence GmbH (DFKI), Language Technology Lab, Saarbrücken, Germany
Mitja Jermol, M. Sc., Marko Grobelnik
10. Central European Centre for Women and Youth in Science
CEC-WYS, 6. FP, SAS6-CT-2004-003582
EC; Dr. Marcela Linková, Institute of Sociology, Academy of Sciences of the Czech Republic, Prague, Czech Republic
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič
11. European Collaborative networked Organizations LEADership initiative
ECOLEAD, 6. FP, 506958
EC; Martin Ollus, Technical Research Centre of Finland, Espoo, Finland
Mitja Jermol, M. Sc., Prof. Nada Lavrač
12. Pattern Analysis, Statistical Modelling and Computational Learning
PASCAL, 6. FP, 506778
EC; Prof. John Shawe-Taylor, The University of Southampton, School of Electronics and Computer Science, Southampton, Great Britain
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
13. Set-up of a Collaborative Permanent Network for Boosting the Participation of Incubated SMEs in Innovation Processes under FP6 Activities
Boost-IT, 6. FP, 023437
EC; Eurique Neves, Inovamais - Servicos de Consultadoria em Inovacao Technologica, Matosinhos, Portugal
Mitja Jermol, M. Sc., Prof. Peter Stegner

VISITORS FROM ABROAD

1. Arian Zweegers, European Commission, Brussels, Belgium, 15.1.2007
2. Bettina Berendt, University of Hamboldt, Germany, 21.5.2007
3. Michael Witbrock, Cycorp, USA, 21.5.2007
4. Abhijit Bhole, IIT Bombay, India, 21.5.2007
5. Michael Witbrock, Cycorp, Inc., USA, 11.9.2007
6. Jesse Read, Waikato University, New Zealand, 24.9.2007
7. Hans Uszkoreit, DFKI, Saarbrücken, Germany, 5.10.2007
8. Ali Imtiaz, FIR, Germany, 29.11.2007
9. Oliver Budde, FIR, Germany, 29.11.2007
10. Malte Susdorff, Cognovis, Germany, 29.11.2007
11. Patrick Sitek, BIBA, Germany, 29.11.2007

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1. Mitja Jermol, M.Sc., Head

2. Jure Ferlež, B.Sc.

Technical officers

3. Marjana Plukavec***, B. Sc.

4. Špela Sitar, B. Sc.

Technical and administrative staff

5. Tina Anžič

6. Sebastjan Mislej

*** Member of industrial or other organisation

MILAN ČOPIČ NUCLEAR TRAINING CENTRE ICJT

The mission of our training centre is training in the field of nuclear technologies and radioactivity. In addition we are actively informing the public about these technologies. The activities of the Nuclear Training Centre in 2007 can be divided into four areas: training in the area of nuclear technologies, radiological protection training, organization of international training courses and public information.

Training in the area of nuclear technologies is our primary mission. At the beginning of the year, the initial training of a new generation of future control-room operators of NPP Krško was conducted. Furthermore, for non-control-room personnel of NPP and for other organizations, a course on the *Basics of nuclear technology* was held. We have also prepared a course on *Advanced training using simulators on safety-related NPP Krško systems* for the Slovenian Nuclear Safety Administration.

There were 13 **radiological protection training** courses for the medical, industrial and research use of radioactive sources.

We have had 5 **international courses** under the auspices of the International Atomic Energy Agency (IAEA).

In the area of **public information** we have continued with the informing and education of elementary and high-school pupils. Groups of children and other visitors came to listen to a lecture about nuclear technology or about radioactive waste and to visit our exhibition. On 15 May 2007 we marked the 100,000th visitor, who was a student from a Slovenian-minority high school in Trieste, Italy. Altogether, there were 187 groups or 7904 visitors this year. Since 1993 our information centre has been visited by a total 104,207 pupils, teachers and other visitors.

We have prepared an expertise for Krško NPP and collaborated in the preparation, design and translation of their Annual Report for 2006.



Head:
Prof. Igor Jenčič

On 15 May 2007 we welcomed the 100,000th visitor to the Nuclear Information Centre, who was one of the students of a Slovenian-minority high school in Trieste, Italy. To commemorate this occasion, all the students in the group received a T-shirt, and the school was given a radiation monitor, which will be used in physics classes.



Figure 1: Youngsters are attracted by computer simulations and other exhibits at the permanent exhibition



Figure 2: On the occasion of the 100,000th visit to the permanent exhibition all of the visitors received a T-shirt

Table of training activities at the Nuclear Training Centre in 2007

Date	Title	Partici- pants	Lecturers	Weeks	Participant x weeks
20. 11. 06- 6. 4. 07	Power-reactor theory	20	17	14.0	280.0
14.-15. 2.	Radiation protection for medical and veterinary workers - radiological diagnostic (Refresher Course)	70	4	0.4	28.0
14.-21. 2.	Radiation protection for Nuclear Medicine Dept. - Refresher Course	3	5	0.2	0.6
26. 3.-13. 4.	SNSA advanced training, using simulators, on safety-related NPP Krško systems	9	5	2.0	18.0
2.-6. 4.	IAEA Regional Workshop on Deterministic Safety Analyses (BE+U) for DBAs	21	4	1.0	21.0
16.-18. 4.	Radiation protection for industrial and other practices (sealed sources)	2	4	0.6	1.2
16.-18. 4.	Radiation protection for industrial and other practices (unsealed sources)	4	5	0.6	2.4
24. 4.	Radiation protection for industrial and other practices (radiography) - Refresher Course	4	4	0.2	0.8
24. 4.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	5	5	0.2	1.0
24. 4.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	2	4	0.2	0.4
26. 4.	Training Extension for RP Officers	2	2	0.1	0.2
7. 5.-1. 6.	Basics of nuclear technology, theory	15	9	4.0	60.0
14.-18. 5.	IAEA Regional Workshop Use of PSA in Support of Plant Maintenance and Inspection Activities	25	4	1.0	25.0
4.-29. 6.	Basics of nuclear technology, systems	17	9	4.0	68.0
12. 7.-10. 8.	Initial training for security of transport of nuclear materials	17	11	0.6	10.2
24.-28. 9.	IAEA Regional Workshop on Safety Analyses and Technical Support Needed for Power Upgrades	17	4	1.0	17.0
1.-5. 10.	IAEA Regional Course on QA/QC of Nuclear Medicine Instrumentation	25	15	1.0	25.0
15.-17. 10.	Radiation protection for industrial and other practices (unsealed sources)	4	5	0.6	2.4
15.-17. 10.	Radiation protection for industrial and other practices (sealed sources)	16	4	0.6	9.6
23. 10.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	2	5	0.2	0.4
23. 10.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	4	4	0.2	0.8
25. 10.	Training Extension for RP Officers	10	2	0.1	1.0
28. 11.-5. 12.	International Seminar on Physical Protection Planning	29		1.6	46.4
10.-14. 12.	IAEA International Training Course on Research Reactor Water Quality Management				
TOTAL		350	136	35.4	646.4

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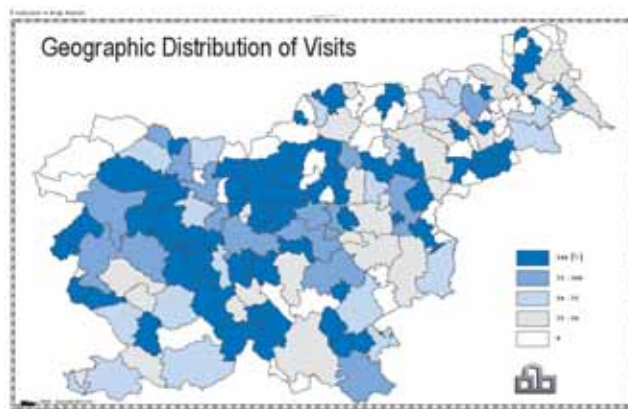


Figure 3: The visitors to the Information centre come from all over Slovenia

INTERNATIONAL PROJECTS

1. P11 - Permanent Exposition - »Fusion - Energy for Future«
P11-FU, EURATOM - MHST
7. FP, EURATOM, Slovenian Fusion Association - SFA
Annex No.2, 3211-05-000017, FU06-CT-2004-00083
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Prof. Igor Jenčič
2. IAEA Regional Workshop on Deterministic Safety Analyses (BE+U) for DBAs
IADETO7
RER/9/088-9001-01
Milorad Dušič, IAEA, Vienna, Austria
Melita Lenošek, B. Sc.
3. IAEA Regional Workshop on Use of PSA in Support of Plant Maintenance and Inspection Activities
IAPSA07
RER/9/087-9002-01
Francisco Yllera Sanchez, IAEA, Vienna, Austria
Marjan Tkavc, M. Sc.
4. IAEA Regional Workshop on Safety Analyses and Technical Support Needed for Power Uprates
IAUPR07
RER/9/088-9006-01
Milorad Dušič, IAEA, Vienna, Austria
Melita Lenošek, B. Sc.
5. IAEA Regional Training Course on QA/QC of Nuclear Medicine Instrumentation
IANM07, C7-RER/6.014-004/07
Stig Palm, IAEA, Vienna, Austria
Matjaž Koželj, M. Sc.
6. IAEA International Seminar on Physical Protection Training
IATPP07
07ME14808
Miroslav Gregorič, Vladimir Kryuchenkov, IAEA, Vienna, Austria
Radko Istenič, B. Sc.
7. IAEA International Training Course on Research Reactor Water Quality Management
IARRW07
RER/0/023 9004 01
Dario Jinchuk, IAEA, Vienna, Austria
Tomaž Skobe, B. Sc.

NEW CONTRACTS

1. Implementation of 2007 Training Program for Krško NPP
Krško Nuclear Power Plant
Prof. Igor Jenčič
2. Operation of the Nuclear Information Centre in 2007
Agency for Radwaste Management
Prof. Igor Jenčič
3. Permanent professional training of Slovenian Nuclear Safety Administration staff
Ministry of the Environment and Spatial Planning; Slovenian Nuclear Safety Administration
Prof. Igor Jenčič
4. Training course »Power Reactor Technology«
GEN energija d.o.o.
Prof. Igor Jenčič
5. Co-financing of the Nuclear Information Centre in 2007
GEN energija d.o.o.
Prof. Igor Jenčič

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9. Saša Bobič

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12. Egon Srebotnjak, M.Sc.

RADIATION PROTECTION UNIT

SVPIS

The main tasks of the Radiation Protection Service are to carry out personal dosimetry and to monitor the working areas and the general environment of the Reactor Centre.

In 2006 a total of 116 radiation workers were monitored using thermo-luminescent dosimeters. Most doses were at the level of the natural background. The highest annual dose recorded was 0.16 micro Sievert; a value much below the annual limit for radiation workers (20 mSv per year).

Additional TLDs were used to monitor external radiation exposure at different locations of the Reactor Centre. Only background levels were recorded.

The environmental impact of activities within the Reactor Centre was estimated by evaluating source term monitoring. The dose to the population due to atmospheric and liquid discharges was estimated to be much lower than one micro Sievert per year, which is only one thousandth of the annual limit for the population.



Head:

Bogdan Pucelj, M. Sc.

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Reka Sava
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INTERNATIONAL PROJECT

1. Sale of LEU contained in TRIGA Fuel Elements (10 pcs.) and Natural Yellow Cake (506 kg)
AG/3645, HN/PA/06.101 Rev.4
TRIGA International SAS, Courbevoie, France; Hélios Nadal, CERCA, Lyon; Paris La Défence, France; EURATOM SUPPLY AGENCY, Luxembourg
Bogdan Pucelj, M. Sc., Darko Kavšek, B. Sc.

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5. **Bogdan Pucelj, M. Sc., Head**

TECHNOLOGY TRANSFER OFFICE

U-9



Head:

Prof. Peter Stegnar

The Technology Transfer Office's mission is to continuously create new partnerships between the Jožef Stefan Institute's researchers and industry, to support the knowledge and technology transfer from research to the business and educational sphere, to raise the awareness of the importance of intellectual property protection, to enable a higher rate of commercialisation of the JSI's intellectual property and to enhance transnational technology transfer. Our main activities therefore include individual company assistance, assistance in technology transfer from the JSI into the business environment, the implementation of expert and technological projects, the communication of technology and the promotion of science.

Different projects of the Technology Transfer Office are enhancing the JSI's cooperation with the business sphere and technology transfer from the JSI to industry. The goal is to encourage innovation and competitiveness in Slovenian companies and research institutions through connecting knowledge, technologies and people.

As a part of the European Innovation Relay Centre (IRC) network with 71 IRCs and more than 240 host organisations the **IRC Slovenia** has been operating since 1997. Our main goal, assisting companies and research institutions to reach concrete agreements on research and technology cooperation, was done with standard tools such as: visiting companies and researchers, identification of their technology offers and needs, formulation of these offers and requests to be ready for the European IRC database of technology offers and requests and further assistance when making contact with interested clients.

1. Together with our partner from Maribor we assisted in 13 international agreements for development or technological cooperation between Slovenian and foreign organisations.
2. We were actively engaged with the Technology Park Ljubljana in their project Connect-2-Ideas. Within the project we co-organised three workshops with Slovenian multinationals, which enabled representatives of multinationals to look for business opportunities together with Slovenian SMEs.
3. In March we co-organised a business meeting in Hungarian Lenti. The topic of the meeting was the wood industry and its development. In May we hosted a workshop for 19 IRC participants coming from 12 countries. Another event in May was co-organised together with the Centre for Knowledge Transfer in information technologies from the JSI and the IRC IRENE from the Area Science Park from Trieste. The Italian-Slovenian meeting between companies and JSI researchers was focused on the international technology opportunities in the field of ICT and security.

The project IRC Slovenia will end on 31 March 2008. The New Enterprise Europe Network project operation for continuation and broadening of services in Slovenia has been accepted for financing by the European Commission, and it will start on 1 April 2008 under the coordination of the Jožef Stefan Institute.

In 2007 an active technology transfer policy, which is a part of the Institute's mission, has been introduced with the **Jožef Stefan Institute Technology Transfer Project**. The main goal of the project is to form an overall strategy and a procedure for technology transfer from the JSI to industry and to help scientists in concrete cases. It is also necessary to introduce technology management and with it an overview of the JSI's technologies available for transferring.

1. An analysis of the state of the art and procedures used at the JSI and elsewhere has shown that complete technology transfer can be achieved by providing three steps: technology assessment and IP protection, technology promotion and, finally, dissemination through technology-transfer R&D projects. Networking was found to be crucial for performing those steps; therefore, two networks have been organized. An internal TT network of the JSI is made up of one Technology Liaison Officer per research department, who is informing us about departmental potential/opportunities. The external network is formed of representatives of the bigger Slovenian industrial enterprises, with the emphasis on R&D representatives. Also, the IRC SME network is used in order to contact small and medium-sized enterprises.



Figure 1: The main development area – added value has been created, especially in the area where activities overlap. (A. Kornhauser)

2. We have published a catalogue “Business opportunities of JSI”, which was reprinted in the same year because of the large interest. A portal for Technology Transfer of the Jožef Stefan Institute is being set up. Data on the technologies of the JSI is also being included in different scientific portals (e.g., ESA, ProTon).
3. Together with the IRC project Technology Transfer, R&D projects are constantly promoted within the JSI and help with industry-JSI project applications is provided. IP-protection counselling is offered and IP-protection strategies are discussed with scientists in order to promote the technical innovation towards industry. For this purpose the collaboration with the Commission for Industrial Property of the Jožef Stefan institute has been established.

Project activities that were directed towards stimulating the participation of small and medium-sized companies (SMEs) in FP projects were carried out in cooperation with the Centre for Knowledge Transfer in information technologies from the JSI. Within the **Set-up of a Collaborative Permanent Network for Boosting the participation of Incubated SMEs in Innovation Processes under FP6 Activities - Boost IT** project we were targeting mainly high-tech companies, spin-offs and members of technology parks and incubators. In 2007 we managed to prepare and submit seven new project proposals and collect 15 new project ideas. This was achieved by informing SMEs about new EU calls, with workshops, trainings and consulting about IPR, business plans, project proposals writing and their financial management.

Conducting research on the state of the art in particular fields of technology and on tools used for technology transfer, we are optimizing the project work for technology transfer and for company assistance.

As a support to the IRC project, on Eliminating Waste and Boosting Productivity in Transnational Technology Transfer - **Lean TTT** project aims at developing ways of optimising standard methods of transnational technology transfer of the IRC network. The idea comes from the Toyota production process (TPS, lean production). Based on the analysis of the technology-transfer processes within the IRC project five pilot activities were tested. The positive results of those tests will be the basis for the recommendations and orientating the improvement process of the whole IRC network.

The goal of the Technological Innovation Network in the field of Information Systems - **TINIS** project is to give a comparison of the innovation environment in partners' regions in the field of information-communication technologies. To reach this goal three events were organized in 2007, workshops in Namur, Belgium and Patras, Greece and the final meeting in Brussels. The results of the project are published in seven catalogues: Help Tools, Innovation Methods, Methods' Formalization, User guide, Existing Networks, Networks observation and the Strategic Plan for Network's Creation, where the JSI was the leading partner. Also, two books have been published within the project, Innovative methods and Case studies: Implementation of ICT technological Networks.

In 2007 a project within the EU's FP6 named **Regions for Research - R4R** was launched. It directly involves 9 partners from 8 regions in different countries of Europe. R4R aims at developing models for Knowledge Transfer in the management of research policies at the regional level. The project has an ambition to develop a solid methodology for the identification, modelling, adaptation and transfer of best practices, allow the creation of a cooperation platform among European regions likely to provide a concrete input to research-policies management at the regional level in the years to come.

In the field of the popularization and promotion of science and technology we are establishing and retaining the Jožef Stefan Institute's positive public image and enabling the transfer of knowledge and technology to the educational system and industry.

To promote and facilitate the organization of visits to the main site of the JSI an internet portal for JSI visits has been set up as well as a network of departmental coordinators for visits within the **Communication of Technology** project that has been organized. Three different programs of

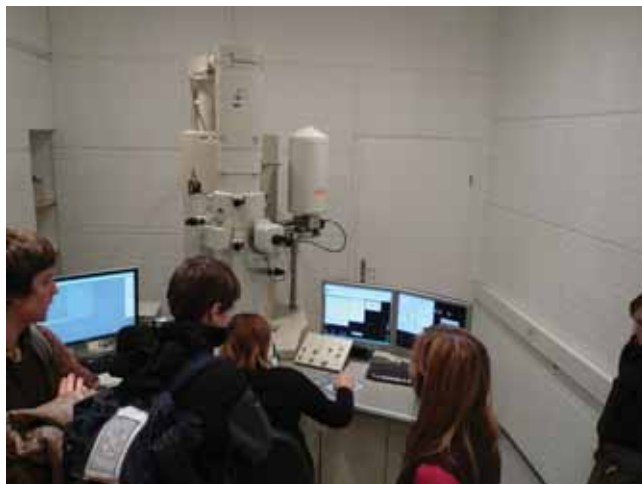


Figure 2: Primary-school children visiting the Center for Electron Microscopy (foto: M. Smerke)

The activities of the Technology Transfer Office are directed towards the following strategic goals:

- Increasing the number of applied research projects at the JSI.
- Creating an appropriate environment for the development and execution of demanding technological and business-oriented projects.
- Searching and implementing new ways of technology and knowledge transfer from the JSI into the business environment.
- Setting up technology management
- Positive evaluation and commercialization of intellectual property



Figure 3: Children from Trnovo Nurseryschool carrying out experiments with sound (foto: O. Magušar)

JSI visits that can be managed at the same time are being offered to visitors. More than 20 visits from different schools and industries have been managed since September 2007. We have organized an open day in collaboration with the Science Festival, organized by the Slovene Science Foundation. In two days more than 240 visitors toured the JSI. Our proactive work is also concentrated on connecting scientists to elementary and high-school interest groups. In particular, different proposals for collaboration have been made to Vič Gymnasium to broaden the collaboration of the JSI's researchers with natural sciences classes, which has been co-established by the JSI. Also, an Institute Information Centre for journalists has been set up, and a web newspaper, IJSplet. Several contributions, articles and interviews have been produced and published for Slovene and EU media.

Within the technology transfer at the Jožef Stefan Institute we participate in technological projects.

Within the **JSI Cyclotron** project a preliminary study of possibilities and the effects of a cyclotron centre built at the JSI has been made and the topic was presented at several meetings with departmental heads and researchers, Gorenje, the representatives of Russian firms and the JSI's leadership. By obtaining a cyclotron, new research possibilities would arise in physics, environmental sciences, chemistry and biology. The cyclotron could also be used to produce radionuclides for medical diagnostics.

Our office is also involved in NATO projects and other expert projects and is active in transmitting its knowledge and experience to the less-developed parts of the world.

In 2007 the **NATO RESCA** project was continued jointly with collaborating partners from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, according to the project work plan. All of the planned radiological field-assessment missions have been carried out and analytical services of the most important radionuclides in representative specimens of investigated environments have been provided, thus enabling a basis for a preliminary assessment of the radiation doses on populations of the general public living in these environments. The results obtained have been favourably evaluated by NATO's radiological experts committee and an extension of the project for one additional year was proposed.

Internationalisation of the IRC project activities was also an important issue in 2007.

Several informative events have been organised and conducted in Kyrgyzstan related to technology-transfer matters, i.e., how to transfer highly developed technologies from Europe to the Central Asian countries. Several representatives from various academic and other organisations (i.e., SMEs) actively participated in these events that were mainly focused on the renewal of the uranium exploitation industry and relevant associated environmental protection and security issues. These activities are, in principle, also supported by the EC and the NATO Science for Peace programme. Similar activities also started in Kosovo, at the university in Priština and at the Pedagogical Faculty in Prizren. All with the long-term goal to establish a regional technology transfer office, based on the experience and knowledge from our technology-transfer office.

Organization of conferences, congresses and meetings

1. Workshop Boost IT, Ljubljana, 27. 3. 2007
2. IRC Induction Workshop, Ljubljana, 8. 5. 2007 – 11. 5. 2007
3. Seminar Boost IT, Rijeka, Croatia, 30. 5. 2007



Figure 4: Visit from a secondary school to the Jožef Stefan Institute (foto: K. Žagar)

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Analysis of possibilities for a spin flip in high energy electron ring HERA

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R4R; 6. FP; 042981
EC; Joanna Szyfter, Stockholm Region Office, Brussels, Belgium; Stockholmsregionens Europakommitte, Stockholm, Sweden
Matjaž Rus, B. Sc.
2. Eliminating Waste and Boosting Productivity in Transnational Technology Transfer
LeanTTT; 6. FP; 030648
EC; Bjorn Westling, IVF Industrial Research and Development Corporation, Moelndal, Sweden
Marjeta Trobec, Spec. for International Affairs
3. Set-up of a Collaborative Permanent Network for Boosting the Participation of Incubated SMEs in Innovation Processes under FP6 Activities
Boost-IT; 6. FP; 023437
EC; Eurique Neves, Inovamais - Servicos de Consultadoria em Inovacao Technologica, Matosinhos, Portugal
Prof. Peter Stegnar
4. Innovation Relay Centre of Slovenia
Si-IRC-04-08; 6. FP; 510419 (IRC 6)
Alice Wu, European Commission, DG Enterprises and Industry Innovation Policy D/2 „Supoport for Innovation“, Brussels, Belgium
Prof. Peter Stegnar

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Spin flip in high energy electron rings
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1. Marjeta Trobec: Development of technology networks in Slovenia (Asst. Prof. Mateja Drnovšek)

5. Technological Innovation Network in the Field of Information Systems
TINIS
INTERREG IIIC, West Zone
EC; Veronique Pirot, INFOPOLE Information Systems, Namur, Belgium
Andrej Gyergyek, B. Sc.
6. Uranium Extraction and Environmental Security in the Central Asian Republics
NATO SFP - Uranium Extraction Legacy
ESP.EAP.SFPP 981742
NATO Public Diplomacy Division, North Atlantic Treaty Organisation, Brussels, Belgium
Prof. Peter Stegnar
7. Assistance in the Development of Conceptual Design for LILW Repository in Slovenia
2003/5812.08.01
Michael Egan, Quintessa Limited, Oxfordshire; Warrington, Great Britain
Prof. Peter Stegnar

NEW CONTRACT

1. Cofinancing and cooperation on common INTERREG project
University of Ljubljana, Faculty of Electrical Engineering, Tržaška 25, Ljubljana
Prof. Peter Stegnar

VISITORS FROM ABROAD

1. Estelle Colmerauer, Midlands Innovation Centre, Coventry, Great Britain, 21. 2. 2007 - 23. 2. 2007
2. Arvid Paasche, Thelma AS, Trondheim, Norway, 11. 6. 2007

3. Bertrand Dessart, IRC Secretariat Luxembourg, Luxembourg, Belgium, 19. 6. 2007
4. Sergei Kebabze, Technomedexport, Sergei Kotov, Technomedexport, Afanasy Andreev Pavlovič, IONIKS, Moscow, Russia, 26. 7. 2007 - 27. 7. 2007
5. Prof. dr. Zahadin Shemsidini, Meleq Bahtijari, University of Pristina, Pristina, Serbia, 23. 9. 2007 - 28. 9. 2007

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